ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY W. H. MAW AND B. ALFRED RAWORTH.

VOL. CII.—FROM JULY TO DECEMBER, 1916.

London:

OFFICES FOR ADVERTISEMENTS AND PUBLICATION—35 & 36, BEDFORD STREET, STRAND, W.C.

1916.

Engineering Library
AUG 9 1916
UNIV. OF ILL. LIBRARY

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CII.—No. 2636.] *LONDON: FRIDAY, JULY 7, 1916.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...6d. BY INLAND POST..8d.

Aveling & Porter, Ltd.
ROCHESTER, KENT,
and 72, CANNON STREET, LONDON.
STEAM ROLLERS. ROAD LOCOMOTIVES.
STEAM CULTIVATING MACHINERY.
STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 5288

A. G. Mumford Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, page 29
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. Od 2179

Cranes.—Electric, Steam,
HYDRAULIC and HAND.
of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 4260

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 4427
See Advertisement last week, page 77.

Plenty and Son,
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9088

Machine Tools in Stock:—
Vertical DRILLS, to admit 16 in., 26 in., and 36 in. diameter. Bolt Screwing MACHINES. 10½ in. centre Special Shafting LATHE. Second-hand PLANER, 25 ft. by 6 ft. by 6 ft.
JAMES SPENCER & CO., LTD., 4260
Chamber Iron Works, Hollinwood, Manchester.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 4968

Drop Stampings from 2/28 lb
Quick delivery given for repetition orders.—Apply, E. C. & J. KEAY, LTD., Birmingham. E 487

Locomotives in Stock.—
KERR, STUART & CO., LTD., have in stock or in an advanced state of progress at their California Works, Stoke-on-Trent, a large number of LOCOMOTIVES, with cylinders from 6 in. to 16 in. diameter (inclusive), for all gauges from 18 in. to 4 ft. 8½ in.—Apply to KERR, STUART & CO., LTD., 6, Broad Street Place, E.C. 4570

THE WELL-KNOWN
Fine Red Moulding Sand,
FOR
IRON, BRASS, ALUMINIUM.
APPLY,
Mansfield Sand Co., Ltd.,
MANSFIELD, NOTTS. 5175

Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS. Od 1534
11, BILLITER SQUARE, LONDON, E.C.

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd., Newton Heath Glass Works, Manchester. Od 9783

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS,
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Office: 128, Trongate, GLASGOW. Od 8547
Registered Office: 103A, Cannon St., London, E.C.

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW (formerly of POPLAR, LONDON).
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
Exceptional Shallow Draught.
VESSELS PROPELLED BY STEAM Od 8759
Turbines or
Internal Combustion Engines.

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 8 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches, or Barges,
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 74, last week. 5020

OIL FUEL APPLIANCES.
Systems
PRESSURE, AIR, STEAM.
For Boilers of all types.
KERMODES LIMITED,
25, The Temple, Dale Street, Liverpool; and
109, Fenchurch St., London.
Naval Outfits a Speciality.
4078

Locomotive Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od 5497
See their Illustrated Advertisement page 88, last week.

R. Y. Pickering & Co., Ltd.
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office:
3, VICTORIA STREET, WESTMINSTER, S.W. 6363

Machine and Engineering
WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, Ltd., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

Gas Engine Generating Set,
Direct Coupled, 65 Kw., 500 volts. Suitable for Town or Producer Gas.
Engine 85 H.P. Stockport.
Dynamo by Westinghouse.
Would sell Engine and Dynamo separately. 5256
Very low price and ready for IMMEDIATE DELIVERY.
JENNINGS,
West Walls, Newcastle-on-Tyne.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON AND TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 5059

Experimental and Research
WORK UNDERTAKEN
BY
THE AERONAUTICAL INSTITUTE OF GREAT BRITAIN
at their Experimental Workshop and Industrial Laboratory.
Offices: 3, Arlington Street, St. James's, S.W. Tel: Gerrard, 6469.
Workshop & Laboratory: 45, Horseferry Road, Westminster. Wire: Zepstraffa, London.

John Bellamy, Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes, Iron and Steel.
Edwin Lewis & Sons, 4923
London Office: 143, Cannon St., E.C. **Wolverhampton.**

Tubes and Fittings,
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 90. 6090

Improved High Pressure
RENEWABLE DISC GLOBE VALVE.
See our Advertisement in last week's issue, page 93.
BRITISH STEAM SPECIALTIES, LTD.,
Bedford Street, Leicester. 3920

Gas Engines, Suction Plants,
Inspections, Tests and Reports. Expert advice.—E. J. DAVIS, M.I. Mech. E., Great Eastern Road, Stratford. Telephones: East 1330; Stratford 580. Tel.: Rapidising, London. 1794

Wanted, Repetition Work
for Capstan Lathes and Drilling Machines.—Address, E 556, Offices of ENGINEERING.

Cement.—Maxted & Knott,
LTD., Consulting Engineers to the British Portland Cement Manufacturers, Ltd., ADVISE GENERALLY on proposed Cement Schemes FOR ABROAD. ADVICE ONLY. Highest references. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy," Hull. 5234

For Sale, One New 3 in. Root's
BLOWER.
One 4 in. Ditto.
Two 5 in. Ditto. All with ring oiling bearings, fast and loose pulleys. For Immediate Disposal.
H. J. H. KING & CO., LTD., Engineers, Nailsworth, Glos. E 495

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS, ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY AND TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGING, SMITH WORK, IRON AND BRASS CASTINGS.
Registered Office and Chief Works: Motherwell.
Cardiff Office: Gordon Chambers, 31, Queen Street.
London Office: 14, Leadenhall Street, E.C.
See Illustrated Advt. in alternate issues. Od 3362

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS. 5334
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.
See half-page Advertisement, last and next week.

Mechanics and Metals
National Bank
OF THE CITY OF NEW YORK.
ESTABLISHED 1810.
CAPITAL (Fully Paid) . . . $5,000,000
SURPLUS & UNDIVIDED PROFITS $9,000,000
This Bank receives Accounts of Banks, Bankers, Corporations, Firms and Individuals on favourable terms, and grants to its depositors every facility consistent with prudent and conservative banking methods.
CORRESPONDENCE INVITED.
FOREIGN DEPARTMENT.
Finances Exports and Imports. Buys and Sells Foreign Exchange, Telegraphic Transfers, &c., and makes Collections on all parts of the world.
LONDON BANKERS. 4778
LONDON JOINT STOCK BANK, LTD.
LONDON, CITY & MIDLAND BANK, LTD.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES. } Row's Patents.
Merrill's Patent TWIN STRAINERS for Pump Suctions
SYPHONIA STEAM TRAPS. REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 4934

Yarrow Patent
Water-Tube Boilers. 4935
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

RAILWAY CARRIAGES, ELECTRIC CARS, &c.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3362

Taylor & Challen, Ltd.,
BIRMINGHAM. 3195
Presses for Sheet Metal
PRODUCTS.
See Advertisement, June 30, page 55.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 5304
See Full Page Advt. page 44, June 30.

FOR
Drop Stampings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, WELLINGTON STREET, GLASGOW. 5298

Delta Metal. HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 4906
Offices and Works: EAST GREENWICH, LONDON, S.E.

Cartridge Containers for
Stokes' 3 in. Trench Howitzer Shells. Can give good deliveries in July.—F. A. FITTON & SON LTD., Unsworth, Whitefield, Lancs. E 445

100 Capstan Lathes for Sale.
Early and regular weekly deliveries. Capacity 3 in., bar through wire feed.—Particulars from E 482, Offices of ENGINEERING.

Steam Navvy, Second-hand,
WANTED TO PURCHASE; must be in good running order and condition.—Send full particulars, price, where can be viewed, to WORKS ENGINEER, AUSTIN MOTOR CO., Northfield, Birmingham. E 550

Punch and Shear Machine
SPECIALISTS. 4784
Consult us. "The Best and the Cheapest." Large Stock. Satisfaction Guaranteed. Established 1860.
SCOTT BROS., WEST MOUNT, HALIFAX.

CHANTIERS & ATELIERS
Augustin-Normand
67, rue de Ferrey—LE HAVRE (France).
Destroyers, Torpedo Boats, Yachts and Fast Boats. 3690
Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Rubber MANUFACTURERS.
Hose Suction and Fire
GUTTA PERCHA & RUBBER, LIMITED
Toronto . . Canada. 5211

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
4731
See half-page Advertisement page 58, June 16.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam.

9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir W. FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5169

UNIVERSITY OF DURHAM.

Armstrong College NEWCASTLE-UPON-TYNE.

PRINCIPAL—W. H. HADOW, M.A., D.Mus., J.P.

SESSION 1916-1917.
COMMENCING 25th SEPTEMBER, 1916.

Departments of MECHANICAL, MARINE, CIVIL and ELECTRICAL ENGINEERING, NAVAL ARCHITECTURE, MINING, METALLURGY, AGRICULTURE, and of PURE SCIENCE, ARTS and COMMERCE.

Full particulars may be obtained on application to—

F. H. PRUEN, M.A., Secretary.

Armstrong College, Newcastle-upon-Tyne. 5353

THE MANCHESTER MUNICIPAL

School of Technology (UNIVERSITY OF MANCHESTER).

PRINCIPAL: J. C. M. GARNETT, M.A. (late Fellow of Trinity College, Cambridge).

The SESSION 1916-17 will OPEN on 5th OCTOBER. Matriculation and Entrance Examinations will be held in July and September.

The Prospectus, forwarded free on application, gives particulars of the courses leading to the Manchester University degrees in the Faculty of Technology, in the following departments:—

MECHANICAL ENGINEERING,
ELECTRICAL ENGINEERING,
SANITARY ENGINEERING (including Municipal Engineering).
THE CHEMICAL INDUSTRIES (including General Chemical Technology, Bleaching, Dyeing, Printing, Papermaking, Brewing and Metallurgy).
THE TEXTILE INDUSTRIES.
PRINTING & PHOTOGRAPHIC TECHNOLOGY,
MINING,
ARCHITECTURE.

During the Session 1916-1917, First Year Courses will be specially adapted to the requirements of students who may wish to take Commissions in H.M. Forces. E 527

City and Guilds Technical COLLEGE, FINSBURY,

LEONARD STREET, LONDON, E.C.

MECHANICAL ENGINEERING:
Professor MARGETSON, M.Sc.
CIVIL ENGINEERING:
Professor MARGETSON, M.Sc.
ELECTRICAL ENGINEERING:
Professor (Vacant).
APPLIED CHEMISTRY:
Professor G. T. MORGAN, D.Sc., F.R.S.

The training is adapted to the needs of various students including (*a*) Pupils from secondary schools above the age of 16 who desire to receive a practical and scientific training bearing upon their future industry or profession; and (*b*) young men who having previously served a pupilage or apprenticeship in works, desire to go through a more systematic training in engineering and applied chemistry.

The College contains laboratories and workshops equipped for instructional purpose, including Engineering and Hydraulic Laboratories, Drawing Offices, Wood and Metal Workshops, Mechanics, Physics, Electrical and Chemical Laboratories, and Dynamo Rooms.

The next Entrance Examination will be held on September 19th in the subjects of Mathematics and English, but the Matriculation Examination of any British University is accepted instead.

The Fees are £20 per annum.

The Programme, giving particulars of Admission, Entrance Examination, Syllabuses of Instruction, and other information may be had post free on application to the REGISTRAR of the College at the above address. E 507

A National Need. BRITISH SCHOOL OF AERONAUTICS.

Aeroplanes and Airships. Construction, Design and Draughtsmanship. Complete Postal Courses. Also preparation for Exams. of Institutions of Civil, Mechanical and Electrical Engineers.—PENNINGTONS, 254, Oxford Road, Manchester. 4327

APPOINTMENTS OPEN.

BOROUGH OF ECCLES.

The Electricity Committee require an

Engineer to Take Charge of

the working of the Plant in their Electricity Generating Station during a daily eight hours' shift. The engagement is a permanent one, and applications will only be considered from candidates who are ineligible for service in H.M. forces. Wages 45/- per week o 156 hours, rising to 50/- per week after six months' approved service. Applications, endorsed "Shift Engineer," stating age, experience, and when able to commence duty, accompanied by copies of not more than three recent testimonials, to be addressed to the BOROUGH ELECTRICAL ENGINEER, Electricity Works, Cawdor Street, Patricroft, Lancs., and forwarded so as to arrive not later than Wednesday next the 12th inst. E 587

Experienced Engineer

WANTED, at once, to take charge of marine constructional department. Knowledge of ship construction essential; also must be familiar with modern refrigerating plants and insulation.—State age, if married, details of experience, and salary required, to "T." Box 755, T. B Browne's Advertising Offices, 163, Queen Victoria Street, E.C. E 578

COUNTY BOROUGH OF WEST HARTLEPOOL.

TECHNICAL COLLEGE.

Assistant Teacher Required

in the Mechanical and Marine Engineering Department. Laboratory, Workshop, and Teaching experience desirable.

Salary £140 per annum.

Further particulars may be obtained from the undersigned.

Applications, together with two testimonials, to be sent to the undersigned before the 12th July, 1916.

J. G. TAYLOR,
Secretary. E 534

GOVERNMENT OF TASMANIA.

The HYDRO ELECTRIC DEPARTMENT of the above Government invite

Applications, from

Qualified Electrical Engineers, for the POSITION of CHIEF ASSISTANT to the Department.

Applicants must have extensive experience in the design, construction and operation of E.H.T. plants and transmission, and in the commercial public supply of electricity, preference being given to applicants having experience on hydro-electric service.

Salary £550 per annum, payable in Hobart, with a three years' engagement, and first-class return passage.

Applications, stating age and qualifications, and enclosing not more than three recent testimonials, to be forwarded to The AGENT GENERAL for TASMANIA, 56, Victoria Street, S.W., not later than 25th July.

The Department's present plant is of 7500 Kw. capacity, hydraulic fall 1000 ft., transmission 88,000 volts 64 miles. E 596

Wanted, by a well

known firm of British Engineers, a

Technically Trained GENTLEMAN,

to Organise and Develop the Sale of High-speed Engines, Air-compressing Machinery, Gas Engines, &c.

Good salary and commission paid to an experienced man with the necessary Commercial and Technical knowledge.

All replies will be treated in confidence.

Address, E 561, Offices of ENGINEERING.

The National Boiler and

GENERAL INSURANCE CO., LTD., St. Mary's Parsonage, Manchester, REQUIRE additional INSPECTORS; must be practical engineers or boiler makers of good experience with engines and boilers; should have theoretical knowledge and be able to take dimensions and make neat sketches and mechanical drawings of boilers and engines; the duties include the examination of all parts of boilers, the indication and examination of engines. Commencing salary £11 per calendar month or upwards according to qualifications and experience. Applications from men eligible for military service are not invited.—Address, by letter only, marked "Inspector," giving age, outline of experience and studies, and copies of testimonials, EDWARD G. HILLER, Chief Engineer. E 562

Wanted, for Locomotive

Manufactory, ASSISTANT MANAGER. No person on Government work will be engaged.—Apply, stating full details and career, to your nearest LABOUR EXCHANGE, mentioning this Journal and E 565

Works Engineer (not already

engaged on Government work) REQUIRED as Manager of a large foundry in the Provinces principally producing very small repetition work. Must have extensive practical experience of machine moulding off plates and the mechanical handling and treatment of sand. To a forceful, pushing Six-o-clock man and good disciplinarian, a liberal salary would be paid, and an opportunity given to acquire an interest in the concern.—Send full particulars (on one side of the paper only) of career, capabilities, age and copies of testimonials, to E 576, Offices of ENGINEERING.

An Engineer is Required in

a public laboratory in London to undertake the mechanical testing of new varieties of timber. Candidates should have qualifications of a University standard and have had some experience in the mechanical testing of constructional materials. Salary £200 to commence.—Applications should be addressed to Box K.L., care of STREET'S, 30, Cornhill, E.C. E 579

Wanted, Assistant Metallurgical CHEMIST,

with knowledge of Mechanical Testing preferred, for engineering works in Midlands. State age, full details experience, and wages required. No person on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 2067. E 564

Wanted, Metallurgical

ASSISTANT for foundry, making high-class castings in steel, iron, gun metal, and aluminium. Metallurgical training essential, and with some foundry experience preferred. Good opportunity for smart young man. No person on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 2056. E 560

Machine Tool Expert, for

Controlled Firm, employing about 100 hands; experienced in jig and tool work and bonus system. Experience in making valves and steam specialities preferred. State age, experience, copies of references, and salary expected. None on Government work considered.—Address, E 548, Offices of ENGINEERING.

Draughtsman (Chief) Wanted

for large Textile and General Engineering works on East Coast. No person already employed on Government work will be engaged.—Apply, stating experience, &c., your nearest LABOUR EXCHANGE, mentioning this Journal and E 595.

Draughtsman, with experience

on all types of electric cranes. Government controlled firm, Manchester district. State age, wages, and experience. No person already employed on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, mentioning this Journal and E 505.

Draughtsmen Wanted, on

Government work, with experience of jigs and tools, petrol engines, or motor car design. No person already engaged on Government work need apply.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and E 588.

Draughtsman Wanted

immediately by a large firm of tar distillers and chemical manufacturers. Applicant must be quick, neat and accurate, and have good general engineering knowledge. State age, experience and salary required.—Apply, to your nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this Journal and E 601.

Dewsbury Certified Firm

REQUIRES MECHANICAL DRAUGHTSMAN, for power-station pipework, light structural work, and boiler-house arrangements. Certified war work. Wages, 40s. to 50s., according to ability and experience.—Address, E 599, Offices of ENGINEERING.

Wanted, in Government

Controlled Establishment, Experienced DRAUGHTSMAN for general works equipment duty. Preference will be given to men of good education with some knowledge of machine tool design. State full particulars with age, experience, and salary expected, to your nearest LABOUR EXCHANGE, quoting No. A 2065. No person on Government work will be engaged. E 580

Wanted, Immediately, for

War work in a Government Aeronautical Drawing Office in London, NINE DRAUGHTSMEN (Senior and Junior). Salaries from £3 10s. to £1 1s. per week plus overtime. Men fit for General Service not eligible. Candidates must have had drawing office experience, technical training, and preferably some shop experience.

Application, with credentials, to ROOM 344, Adastral House, Victoria Embankment, E.C. E 563

Wanted Immediately, First-

class JIG and TOOL DRAUGHTSMAN with extensive experience on automobile engine tools. Must be capable, speedy, and possess initiative. No person on Government work will be engaged. Excellent prospects to the right man.—Apply, stating full experience, age and salary required, to Box No. A 2020, your nearest LABOUR EXCHANGE E 533

Wanted Immediately by Con-

trolled Firm in Midlands, first-class Jig and Tool DRAUGHTSMEN; also DRAUGHTSMEN with experience in Aero or Automobile Work. Good salary to suitable man. No one employed on Government work can be engaged.—Apply, stating qualifications, to the nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this Journal and E 478.

Wanted, Sound Engineer's

DRAUGHTSMEN. Chassis experience preferred. No person already employed on Government work, or resident more than 10 miles away, will be engaged.—Apply, stating full particulars, experience, age, and salary required, to The SOPWITH AVIATION CO., LTD., Kingston-on-Thames. E 600

Wanted, Tool Draughtsman,

systematic and capable of working out designs from rough sketches; some shop experience preferred. No person on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 2049. E 566

Wanted, Experienced Jig and

TOOL DRAUGHTSMEN for aeroplane work. Wages and qualifications to be stated. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and E 540.

A Few Good Detail

DRAUGHTSMEN REQUIRED for urgent work in an Admiralty establishment. Applicants should state age, experience, salary required, and enclose at least two references.—Apply, Box No. 646, care of Messrs. F. White & Son, Genl. Advtg. Agents, 35, Fleet Street, London, E.C. E 531

Required, for Drawing Office

of Government Department, London, Civil Engineering ASSISTANTS; must be good draughtsmen and ineligible for military service. For one appointment experience of water and sewerage work required, and for others a good knowledge of steel work construction.—State age, experience, salary required, and enclose copies of testimonials by letter to BOX 685, care of STREET'S, 8, Serle Street, London, W.C. E 610

Machine Shop Foreman

WANTED, at once. Competent man with some erecting experience. Well up in all latest methods. No one already employed on Government work will be engaged.

Apply, giving all particulars to nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and E 569

Head Foreman Smith

REQUIRED to take charge of forge and smithy of locomotive works, Manchester district. Must be conversant with the treatment of modern steels, and capable of designing own stamping blocks and tools. No one already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and E 589.

Advertising and Publicity.—

MAN (ineligible) WANTED, by firm of Machine Tool Makers for this class of work.—Applications, stating full particulars and wages required, to be addressed to the SECRETARY, WM. ASQUITH, LTD., Highroad Well Works, Halifax. E 590

Wanted, for Controlled

works in Midlands, FOREMAN for engineering shop, good organiser, able control 20 to 30 men; must have practical mechanical and electrical experience in all kinds of repairs to machinery, gas engines, motors, and the manufacture of machinery in connection with constructional work, modern methods, jigs, &c. No one on Government work considered.—Apply, stating experience, age, and salary required, nearest LABOUR EXCHANGE, mentioning this Journal and E 574.

First-class Coppersmith

WANTED IMMEDIATELY for lifeboat work.—Write or apply, stating wages required, experience and earliest date can start, to nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A 2079. No person on Government work will be engaged. E 608

Wanted, at Munition Factory

as Departmental Managers, energetic YOUNG MEN of good education who have been discharged from Army, or are ineligible. Must be capable of undertaking a full days work. Engineering experience an asset.—Address, E 585, Offices of ENGINEERING.

Engineering Pupil.—Vacancy

with Firm (Government Contractors) manufacturing latest types of machinery, oil and gas engines, &c.; moderate premium.—Address, 6321, Offices of ENGINEERING.

A Large Firm of Engineers,

in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of ENGINEERING.

SITUATIONS WANTED.

Engineer-Lieutenant, R.N.

(25), Ex. R.N.E. College (invalided), DESIRES EMPLOYMENT in position of trust, with prospects.—Full particulars to E 546, Offices of ENGINEERING.

Experienced Surveyor Desires

APPOINTMENT in mining engineers' office with a view to working partnership. Highest testimonials. Terms and fullest particulars.—Address, E 544, Offices of ENGINEERING.

Engineer (Mech. and Elect.),

English birth and training, lately returned from abroad, age 42, having an extended experience in the lay-out, erection, and maintenance of plant and machinery, DESIRES EMPLOYMENT.—Address, E 571, Offices of ENGINEERING.

Engineer (26), B.Sc. Eng.

B'ham, 1½ years' commercial motor workshops, late Lt. A.S.C., M.T. (invalided), pupil at Flying School, DESIRES temporary EMPLOYMENT (London), day-time (Nine a.m.–Five p.m.); prefer assist consulting or departmental engineer, internal combustion work—Address, E 607, Offices of ENGINEERING.

PARTNERSHIPS.

Partners
Directors
Businesses
Factories

for these apply to

WHEATLEY KIRK, PRICE & CO.,
46, Watling Street, LONDON, E.C.
Albert Square, Manchester. 4994
26, Collingwood Street, Newcastle-on-Tyne.

PATENT AGENTS.

The Consulting Patent

AGENCY, 263, Gray's Inn Road, London. Regd. British, U.S.A., and Canadian Agents. "Cepators, London"—Holborn 6109. All matters at fixed inclusive charges. 4449

Jensen and Son, 4884

CHARTERED PATENT AGENTS, (Established 1867). British, Colonial, and Foreign Patents, and Trade Marks and Designs Registrations, 77, Chancery Lane, London, W.C. Tel.: Holborn 1948.

John E. Raworth,

CHARTERED PATENT AGENT, 4995
70/71, Queen Anne's Chambers,
Tothill Street, Westminster, S.W.

WANTED, &c.

The Proprietors of Letters

Patent No. 21129, of 1913, "Roll Crusher," and No. 21609, of 1910, "Steam Turbine," are DESIROUS of ENTERING into ARRANGEMENTS, by way of a License or otherwise, on reasonable terms, for the purpose of exploiting above identified patents and insuring their practical working in Great Britain.—Address all Inquiries to ALCHALCO, care of H. L. KEEN, 732, Salisbury House, London Wall, E.C. E 582

Australian Trade.—The

BRITISH AUSTRALIAN MACHINERY CO., LTD., of Sydney, New South Wales, with Branches and Agencies throughout Australia and New Zealand, and extensive Government connections, is PREPARED to REPRESENT BRITISH MANUFACTURERS of good standing who wish to develop Colonial trade. Terms, cash against documents, London.—Submit proposals in duplicate to the Company's Buying Representative, MR. FRANK MOTT, Billiter Square Buildings, London, E.C. E 592

French Concern Wishes to

BUY VENTILATING FANS, "Roots" new or second-hand, also Power Presses 25/150 tons. All communications to be addressed to Messrs. BESSLER, WAECHTER & CO., LTD., "Tinplate Department," Salisbury House, Finsbury Circus, E.C. E 612

ENGINEERING.

THE STEAM FLOW INTO A COMPOUND STEAM-TURBINE.

EXPERIENCE has shown that the weight of steam passing through any pressure-compounded steam-turbine is in practice very nearly independent of the exhaust pressure. A very large diminution in the vacuum, for example, has no appreciable effect on the steam flow, which depends practically exclusively upon the pressure and specific volume of the steam in front of the first row of guide-blades. The inflow, in short, is directly proportional to $\sqrt{\frac{p_0}{V_0}}$, where p_0 denotes the pressure in pounds per square inch, and V_0 the specific volume of the steam in front of the first row of guide-blades. When the steam conditions above the governor-valve are kept constant, whilst the pressure in front of the first row of guide-blades is varied by the governor, the weight of steam passing the turbine is known from experiment to be directly proportional to the pressure below the governor-valve. This result is in perfect accord with the foregoing, since when steam is wire-drawn the product p V will remain constant unless the steam be initially wet. For example, dry steam at 200 lb. absolute has a specific volume of 2.320 cub. ft. per lb., and a total heat of 1205.44 B.Th.U. By wire-drawing it down to 15 lb. absolute its heat content will be unaltered, and, from Professor Callendar's convenient and precise formulæ it appears that steam at 15 lb. absolute, with a total heat of 1205.44 B.Th.U., has a specific volume of 30.74 cub. ft. per lb., so that the product p V after the wire-drawing is 461.3, as against 464.0 in its initial condition. Hence the value of the product p V has only altered by about ½ per cent. Had the steam been superheated prior to the wire-drawing, p V would still remain practically constant; but with steam initially wet, the product p V is diminished on wire-drawing, so that the weight passed through a turbine does not in this case decrease quite as rapidly as the effective pressure is diminished by the action of the governor.

That the inflow into a compound turbine should vary as $\sqrt{\frac{p}{V}}$ can be shown as follows. Suppose the turbine to have n pressure stages, and let q be the thermodynamic head expended at each stage. In the general case q will, of course, vary with n, being different at different stages. Then if U denote the total heat which becomes available as the steam passes through the turbine, we have the relation :—

$$\Sigma_1^n q = U \quad . \quad . \quad . \quad . \quad (1)$$

that is to say, the total heat which becomes available is equal to the sum of the heat units available at each stage. The value of U here denotes accordingly not the adiabatic heat drop u, but the heat expenditure along the actual expansion line; that is to say, $U = R\,u$, where R represents the reheat factor, so that U is commonly some 4 to 6 per cent. greater than u. In fact, the frictional losses in the earlier stages of a compound steam-turbine go to reheat the steam, which is accordingly somewhat drier in the succeeding stages than it would be in the absence of friction.

Now U may obviously be written in the form

$$U = U_n - U_0 ;$$

in which expression, if we give U_0 any value other than zero, we merely change the origin from which U is reckoned. But

$$U_n - U_0 = \int_{U_0}^{U_n} d\,U = \int_0^n \frac{d\,U}{d\,n}\,d\,n.$$

So that we thus get

$$\Sigma_1^n q = \int_0^n \frac{d\,U}{d\,n}\,.\,d\,n.$$

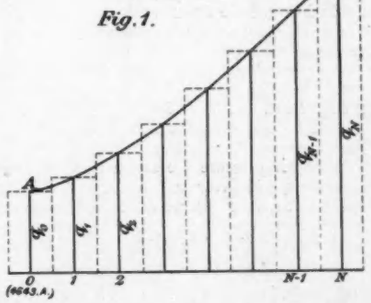


Fig. 1.

Let us assume for the moment that U_0 is not zero, and that the condition of the steam as it enters stage No. 1 arises from the work done by it in passing through an imaginary stage No. 0, in which the thermodynamic head expended was q_0. Then

$$\Sigma_1^n q = \Sigma_0^n q - q_0.$$

Let the values of q from q_0 to q_n be plotted against the corresponding values of n as in Fig. 1. Then the value of $\Sigma_0^n q$ is the area of all the little rectangles shown. For practical purposes this area is equal to that under the curve A B + one-half the little rectangles corresponding to q_0 and q_n. Hence we may write :—*

$$\Sigma_0^n q = \int_0^n q\,d\,n + \tfrac{1}{2}(q_n + q_0).$$

Making this substitution, we have, finally :—

$$\int_0^n q\,d\,n - q_0 + \tfrac{1}{2}(q_0 + q_n) = \int_0^n \frac{d\,U}{d\,n}\,.\,d\,n.$$

Or

$$\int_0^n q\,d\,n + \tfrac{1}{2}\int_0^n \frac{d\,q}{d\,n}\,.\,d\,n = \int_0^n \frac{d\,U}{d\,n}\,d\,n.$$

This relation holds whatever the value of n, so that the signs of integration may be removed, giving the differential equation of flow as

$$q + \tfrac{1}{2}\frac{d\,q}{d\,n} = \frac{d\,U}{d\,n},$$

or

$$\frac{d\,U}{q} = d\,n + \tfrac{1}{2}\,\frac{d\,q}{q}.$$

Hence

$$\int\frac{d\,U}{q} = n + \tfrac{1}{2}\log_e q.$$

In the case of an impulse turbine, all the q's have generally much the same value, so that q_0 is nearly equal to q_n. Hence $\frac{1}{2}(\log_e q_n - \log_e q_0)$ is negligible, and we get simply :—

$$\int\frac{d\,U}{q} = n.$$

Similarly, in the case of a reaction turbine, n is always a large number, so that, although in this case q_N may be two or three times as great as q_0, the logarithmic term is so small in comparison with n that it may be neglected, as before.

Taking, therefore, $\frac{d\,U}{q} = d\,n$ as the differential equation to flow, we note that if q be expressed in foot-pounds, and v be the velocity of discharge at any stage, $\frac{v^2}{2\,g} = k\,q$, where k is a coefficient, which may, for our present purpose, be taken as constant at its average value throughout the turbine.

Further, if w be the weight of steam passing per second, and V its specific volume on discharge from any set of guide-blades, we have

$$v\,\Omega = w\,V.$$

Whence

$$\frac{1}{q} = \frac{2\,g\,k\,\Omega^2}{w^2}\,.\,\frac{1}{V^2}.$$

Further, if the actual expansion curve of the steam be given by the relation $p\,V^\lambda = C$, we have (if we express U in foot-pounds), the relation :—

$$U = \frac{144\,\lambda}{\lambda - 1}\,(p_0 V_0 - p\,V),$$

$$= \frac{144\,\lambda}{\lambda - 1}\left(p_0 V_0 - C\,V^{1-\lambda}\right).$$

$$\therefore \frac{d\,U}{d\,n} = 144\,\lambda\,C\,V^{-\lambda}\frac{d\,V}{d\,n}.$$

Substituting for $d\,U$ and for q we get :—

* The complete expression, as proved in the Calculus of Finite Differences, is

$$\Sigma_0^n q = \int_0^n q\,d\,n + \tfrac{1}{2}(q_n + q_0) + \frac{1}{12}(\Delta\,q_n - \Delta\,q_0) - \frac{1}{24}(\Delta^2 q_n - \Delta^2 q_0) + \&c.$$

$$d\,n = \frac{2\,g\,k\,\Omega^2\,144\,\lambda\,C}{w^2} \cdot \frac{d\,V}{V^{\lambda+2}},$$

or

$$\lambda\,C \int \frac{d\,V}{V^{\lambda+2}} = \frac{w^2}{288\,g\,k} \int \frac{d\,n}{\Omega^2} \quad . \quad . \quad (4)$$

On integration we get :—

$$\frac{\lambda}{\lambda+1}\left(\frac{p_0}{V_0} - \frac{p_x}{V_x}\right) = \frac{w^2\,x}{288\,g\,k}\left\{\frac{1}{\Omega^2}\right\},$$

where $\left\{\frac{1}{\Omega^2}\right\}$ denotes the mean value of $\frac{1}{\Omega^2}$.

In practice, when p is small V is large, so that $\frac{p_x}{V_x}$ is generally small compared with $\frac{p_0}{V_0}$. This is particularly so in the case of condensing turbines.

In any given turbine the value of

$$x\left\{\frac{1}{\Omega^2}\right\}$$

is fixed once for all, so that the inflow varies as

$$\sqrt{\frac{k\,\lambda}{\lambda+1}} \cdot \sqrt{\frac{p_0}{V_0}}$$

The factor $\sqrt{\frac{k\,\lambda}{\lambda+1}}$ varies with the efficiency of the turbine, but for a given turbine the efficiency of the high-pressure end is nearly constant whatever the changes in the load, and as the inflow is fixed almost wholly by the conditions at the first few stages, we get the result that for a given turbine at all loads the inflow varies simply as $\sqrt{\frac{p_0}{V_0}}$. This holds so long as the speed is kept constant. That the effect of variations in the speed is not always negligible is, however, well shown by the following figures recorded in a test of a 500-kw. unit.

Load in Kilowatts.	Steam Flow per Hour. Lb.	Initial Pressure. Lb. per Sq. In.	Initial Temperature. Deg. F.
448	10,170	133	352
0	9,842	136	359

From the above data we find that in the first experiment the specific volume of the steam below the governor-valve was 3.420 cub. ft. per lb., and in the other 3.579. The corresponding values of $\sqrt{\frac{p}{V}}$ are 6.237 and 6.346. Dividing the corresponding inflows by these values, we get 1630 and 1551, so with the turbine working at zero efficiency the value of $\sqrt{\frac{k\,\lambda}{\lambda+1}}$ differs by about 8 per cent. from what it was at full load. This is a somewhat extreme case, and in practical working the effect of speed is not large. There are, in fact, two opposing tendencies at work. A decrease of speed increases the "carry-over" from a stage, and thus the energy available for producing flow in the next stage. At the same time, however, the corresponding decrease in efficiency involves an increase in the specific volume of the steam passing, and the one effect tends to offset the other. With the rotor completely stopped, the second effect is much the more important of the two, and there results, as stated, a decrease of some 8 per cent. in the quantity passing. On the other hand, experience with marine turbines using non-superheated steam shows that the "coefficient of inflow" is hardly affected by the change from full speed to half speed. This is perhaps in part due to the fact that the steam as supplied by the boilers contains a certain amount of moisture. In wire-drawing therefore the product pV is diminished, a circumstance which, as appears from the foregoing, tends to increase the inflow under a given initial pressure. This increase compensates in part for the decrease due to the lowered efficiency of the turbine, which, as the tests above quoted show, might otherwise be material.

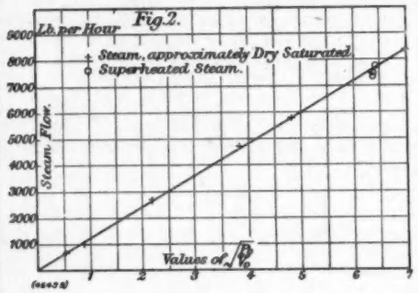
Some experiments made by Dr. Stodola on a 500-horse-power Zoelly turbine demonstrate very forcibly the accuracy of the law above given. His observations reduced to British units are represented by italics in the table in the next column.

In Fig. 2 the weight passed per hour has been plotted against the values of $\sqrt{\frac{p}{V}}$ given in the last line of the table. As will be seen, the points lie very accurately on a straight line through the origin. In these cases the superheat was nearly negligible throughout, but Dr Stodola also made some observations with steam superheated about 70 deg. These latter results have been plotted as circles on the diagram, and it will be seen that the accord is not as good, the discrepancies being, no doubt, attributable to the difficulty of determining accurately the temperature of superheated steam. In illustration of these difficulties it may be mentioned that a thermometer placed in the steam-pipe of a turbine has been known to show variations of as much as 10 deg. Fahr., according as it was nearer to or farther away from the centre of the pipe.

Stodola's Experiments on 500-Horse-Power Zoelly Steam-Turbine.

Absolute pressure below governor valve, lb. per sq. in.	*148.7*	*132.6*	*101.6*	*80.4*	*45.1*	*17.84*	*10.95*
Superheat, deg. F.	*1.1*	*1.1*	*2.3*	*4.0*	*4.3*	*7.3*	*21.2*
Weight passed per hour .. lb.	*8326*	*7426*	*5778*	*4683*	*2650*	*1025*	*650*
Specific volume, cub. ft. per lb. ..	3.059	3.408	4.383	5.472	9.416	22.54	36.37
$\sqrt{\frac{p}{V}}$	6.973	6.238	4.815	3.834	2.189	0.8896	0.5488

In the case of the experiments plotted in Fig. 2 the flow is very nearly directly proportional to p_0, but in cases where the superheat is high and



variable this is no longer true. In some tests by Dr. F. Maguerre (*Z.V.D.I.*, 1908) on a disc-and-drum turbine, for example, the pressure and superheat in front of the drum were varied through a wide range. Thus, with a pressure of 3.12 kg. per sq. cm. and a superheat of 25.7 deg. Cent., the weight flowing was 7662 kg. per hour; whilst with a pressure of 3.14 kg. per sq. cm. and a superheat of 93.4 deg. Cent. the flow fell to 7096 kg. per hour. Hence in this case the flow was less with the higher pressure, the reason being, of course, that at the higher pressure the steam happened to have a greater specific volume.

Returning to equation (4), we have in the case of an ordinary reaction turbine Ω constant for each group, and we can therefore integrate (4) in the form

$$\frac{\lambda}{\lambda+1} \cdot \left(\frac{p_0}{V_0} - \frac{p_x}{V_x}\right) = \frac{w^2}{288\,g\,k} \cdot \left[\frac{n_1}{\Omega_1^2} + \frac{n_2}{\Omega_2^2} + \&c. + \frac{n_x}{\Omega^2_{x-1}}\right]$$

In this expression Ω_1 denotes the net area available for flow through group No. I., Ω_2 that through Group II., and so on, whilst n_1, n_2, &c., denote the number of blades in successive groups.

In the first place this expression shows that quite large alterations in the area through the blades at the low-pressure end of the turbine will be practically without effect on the weight of steam passed. In fact, Ω_x is always very large in comparison with Ω_1, so that in general $\frac{n_x}{\Omega^2_x}$ is negligible in comparison with the earlier terms in the series.

In common practice the groups of the complete turbine are distributed over two or three different diameters of drum. Any group on any drum can, however, for the purpose of calculation, be replaced by an equivalent group on any drum diameter by means of a very simple rule. It is merely necessary that $n\,\bar{d}^2$ be kept constant, where $\bar{d}$ denotes the mean diameter of the blading. Thus a group of six rows of blades 40 in. in mean diameter may be replaced by a group of twelve rows of blades with a mean diameter of 28 in. In practice, of course, physical and mechanical reasons may prevent such a transfer being actually made; but for the calculation of the output and efficiency of the turbine it is a matter of indifference whether an actual group be used or its equivalent, reduced to, say, the high-pressure section of the turbine.

It is further generally possible in making this reduction to arrange that the whole of the equivalent groups shall have the same number of rows of blades, so that n is constant throughout. In that case the successive values of $\frac{1}{\Omega}$ will form very approximately a geometric progression, at least so far as the earlier groups of the series are concerned. As has already been pointed out, very considerable variations in the actual values of the groups at the low-pressure end will have very little effect on the weight of steam passed, so that it is legitimate, for our present purpose, to assume that the geometric progression is accurately maintained throughout. If σ be the common ratio between successive terms, we then get

$$\frac{\lambda}{\lambda+1} \cdot \left(\frac{p_0}{V_0} - \frac{p_x}{V_x}\right) = \frac{w^2}{288\,g\,k} \cdot \frac{n_1}{\Omega_1^2}\left[1 + \frac{1}{\sigma^2} + \frac{1}{\sigma^4} + \&c.\right]$$

Summing the series up to n terms gives :—

$$\frac{\lambda}{\lambda+1}\left(\frac{p_0}{V_0} - \frac{p_n}{V_n}\right) = \frac{w^2}{288\,g\,k} \cdot \frac{n_1}{\Omega_1^2} \cdot \frac{1 - \left(\frac{1}{\sigma^2}\right)^n}{1 - \frac{1}{\sigma^2}} \quad . \quad (5)$$

an expression which may be used to determine the pressure in front of each group all the way down the turbine. We have, in fact,

$$\frac{\frac{p_0}{V_0} - \frac{p_n}{V_n}}{\frac{p_0}{V_0} - \frac{p_x}{V_x}} = \frac{1 - \left(\frac{1}{\sigma^2}\right)^n}{1 - \left(\frac{1}{\sigma^2}\right)^x}.$$

The applicability of this formula will, of course, depend on the accuracy with which the successive values of Ω form a geometric progression.

As a somewhat rough interpolation formula, assuming the product $p\,V$ as constant at its average value throughout the expansion, and writing accordingly $\frac{p}{V} = c\,p^2$, we get :—

$$\frac{p_0^2 - p_n^2}{p_0^2 - p_x^2} = \frac{\frac{n_1}{\Omega_1^2} + \frac{n_2}{\Omega_2^2} + \&c. + \frac{n_n}{\Omega_n^2}}{\frac{n_1}{\Omega_1^2} + \frac{n_2}{\Omega_2^2} + \&c. + \frac{n_x}{\Omega_x^2}}.$$

An expression which may be used to find the approximate value of the pressure at intermediate stages of the turbine when the initial and final pressures are known.

Referring again to (5), it is obvious that $\left(\frac{1}{\sigma^2}\right)^x$ will be very small compared with unity, and as $\frac{p_x}{V_x}$ is also very small, we get the relation

$$\frac{p_0}{V_0} \propto \frac{w^2}{1 - \frac{1}{\sigma^2}} \cdot \frac{n_1}{\Omega_1^2}$$

Noting that $w\,V = \Omega\,v$, we may write

$$v^2 = C\left(1 - \frac{1}{\sigma^2}\right)\frac{p_0\,V_0}{n},$$

where C is a constant to be determined by experience. For turbines of the usual type working with non-superheated steam, the value of C is about 5400. Since, however, the inflow varies somewhat with the efficiency, any simple formula of this kind must be considered merely as an approximation.

It has frequently been suggested that the velocity of inflow into the first stage of a reaction turbine should be estimated on the following lines :—

Let U be the total number of heat units available, and $\overline{N}$ the total number of rows of blades, both fixed and moving, reduced, as explained above, to the high-pressure drum. Then, on the average, the heat available at each of these stages will be $\frac{U}{\overline{N}}$, and the theoretical velocity of inflow will be

$$v = 224\sqrt{\frac{U}{\overline{N}}} \text{ ft. per sec.}$$

The objection to this process is that the total amount of heat available varies with the vacuum. Thus an increase of vacuum from 28 in. to 29 in. will increase the heat available in a high-pressure reaction turbine by some 10 to 12 per cent.; but

from what has gone before it is obvious that such a variation in vacuum will have no perceptible effect on the weight of steam passed per second. If, however, a conventional value be chosen for U, a convenient, if somewhat rough, practical formula is obtained. Thus in the case of high-pressure reaction turbines the actual velocity of inflow in the first stage is approximately given by the reaction

$$v = \frac{3900}{\sqrt{N}} \text{ ft. per sec.}$$

The coefficient varies somewhat with the conditions of operation and with the designed working pressure, but the range of variation is not very large. If, instead of the total number of blades, both fixed and moving, the moving blades only be counted, the coefficient becomes 2750.

THE NATIONAL PHYSICAL LABORATORY IN 1915-16.

(Concluded from vol. ci., page 628.)

Electrotechnics: *A. General Work and Photometry* (Messrs. C. C. Paterson, M. Inst. C.E., E. H. Rayner, M.A., M.I.E.E., A. Kinnes, B.Sc., B. P. Dudding, A.R. C.Sc., J. W. T. Walsh, B.A.).—Several confidential researches have been carried out, test work, mainly connected with the supply of munitions, has been conducted, and the routine work has been continued, although Mr. Rayner has been attached to the Inventions Department of the Ministry of Munitions, and Mr. Dudding to the Metrology division. Ordinary research work has thus had to be suspended. The testing of self-luminous dials for aeroplanes, &c., is one of the problems dealt with, the compounds being examined before application as well as the complete dials.

B. Direct Current and Resistance (Mr. S. W. Melsom, Mr. H. C. Booth, A.R.C.Sc.).—Three times the work of the heaviest pre-war year has been done, chiefly for the Admiralty, with a staff which was numerically (but not as to junior assistants) the same as before. Mr. Melsom draws attention to the importance of the design for main current terminals; in some large current shunts, which had to be erected in restricted space. Current differences of 8 per cent., depending upon the method of leading in the current, were detected; the temperature variations due to Peltier effects were also noteworthy. As it takes half an hour or more before a large shunt attains its maximum temperature under full current for such tests, some addition to the Laboratory equipment is required for this work; the weakness of the soldered joints is the most prolific source of trouble in such apparatus.

Heat (Dr. J. A. Harker, F.R.S., Dr. G. W. C. Kaye, Messrs. W. Hugo, A. Blackie, B.A., W. F. Higgins, B.Sc., Ezer Griffiths, M.Sc., F. H. Schofield).—Dr. Kaye, Mr. Blackie, and four other members are in the Army. Dr. Harker is now engaged on special research, and Mr. Schofield (of the Local Government Board) only joined at Christmas; the general research work has thus had to suffer.

Fundamental Temperature Scale. Thermal Conductivity of Refractory Materials. Cold Storage.—In connection with the work on the International Scale (see last year's report, July 23, 1915, page 91) an investigation has been commenced with the co-operation of Messrs. Johnson, Matthey and Co., into the influences of various factors on the behaviour of platinum during its manufacture into wire and during its subsequent thermal treatment. Some new platinum thermometers have been made and some commercial thermometers have been tested, also in liquid air. The apparatus (flow calorimeter) for studying the heat insulation of refractories up to 450 deg. Cent. has proved very satisfactory and has been used for testing materials (bricks) for boiler plants and for thermal insulation on board. Thermo-couples are embedded in the two faces to determine the gradient, and the quantity of heat is deduced from the rate of rise of temperature in the water passing through a flat coil of piping in contact with the cooler face. To ensure good thermal contact with the irregular slab faces, the hot surface is immersed in a shallow bath of molten tin electrically heated. At present slabs of silicate cotton, made up in the form of matting, are being tested. Slag wool and cork, granulated or in slabs, for cold storage, are tested with the large hot-plate described in previous years, consisting of two steel plates, 3 ft. by 3 ft., bolted together and enclosing a flat resistance coil. Absolute values of thermal conductivity are obtained, and it is to be hoped that the firm for which these experiments is being conducted will extend the range and scope of the inquiry.

Heat Loss from Surfaces and through Roofing Materials.—The continued experiments on heat losses from surfaces* prove the important, though not unexpected, fact that the convection loss depends to a marked degree on the orientation of the plate. Plates of 4 ft. by 3 ft. are tried in various positions and the total heat loss and the loss by radiation are measured; the difference gives the convection loss. Polar diagrams of the emission, convection and radiation around a horizontal axis, have also been obtained. It is not easy to measure in calories per sq. cm. the small radiation from a metal surface at a temperature which is only slightly higher than that of its surroundings, and after various experiments the old, and now rather discredited, Melloni thermo-pile was found most suitable for working with comparatively large emitting surfaces. The pile consists of 64 junctions of bars of antimony and bismuth; a pile of about 4 sq. cm. area, painted black, gives rise at 100 deg. Cent. to a thermo-electric force of 4,000 micro-volts, measured on a potentiometer.

The question of heat transmission through roofing materials is of equal practical interest. Corrugated iron has its great conveniences, but anybody who has had to stew in such a shed during day time and to shiver during the night would welcome the replacement of the galvanised iron roof by something less pervious to heat. Unfortunately the tests of some new cheap roofing materials, consisting of cement and fibrous material, compressed to sheets ¼ in. and more in thickness, are not at all promising in this respect, though the thermal conductivity of cement-like materials is about 1/70 that of iron. In the experiments a model hut was built up of walls of cork slabs, 2 in. thick, and a roof of the new material or of galvanised sheet iron; the air inside was heated by resistances which were not allowed to get sufficiently hot to set up appreciable radiation, and the air was agitated by a fan; the air temperature inside and outside differed by 30 deg. F. Contrary to expectation, the heat loss through the cement, measured per sq. ft., was 20 per cent. greater than through iron, the reason being that the emissivity loss from the surface, and not the thermal conductivity of the material, is the decisive factor. When the iron was painted black the heat transmission increased, becoming equal to that of the cement; when the cement slabs were painted with aluminium they behaved like the iron; the gradient in the material was only 2.5 deg. F. Possibly the material might answer better when made in cellular form with air spaces, if then sufficiently strong. But it is earnestly to be desired that the Laboratory may be enabled properly to attack these problems, which ought to have been settled long ago.

The thermal reactions in the manufacture of Portland cement have been qualitatively investigated with the aid of container cells in an electric furnace; a quantitative investigation is under consideration.

Optical Pyrometers.—The optical pyrometers of the polarising type which the Cambridge Scientific Instrument Company supplied for munition work were in the first instance provided with an angular scale only. The temperature scale of such an instrument can be calculated from observations at two temperatures on a black body, but the Laboratory, in standardising the pyrometers, takes observations at a considerable number of points. From these observations the relations between the tan ϕ and $\frac{1}{T}$ is reduced, and a table of corresponding values of angle-readings and temperatures is calculated for every 50 deg. C. Theoretically, log tan ϕ plotted against $\frac{1}{T}$ should give a straight line; most of the instruments conformed closely to this relation; some did not, and in these, particularly in the early patterns intended for work at relatively low temperatures down to 700 deg. C., there was a slight scattering of the light in the interior. Many of the instruments were provided with more than one range, neutral-tint absorption glass being used to obtain lower intensities at higher temperatures. In order to ascertain whether the two halves of the field matched satisfactorily at the higher ranges and to check the behaviour of the instrument in general, each instrument was directly tested on a black-body furnace, yielding a maximum temperature of 1,450 deg. C., and on another carbon-tube furnace, designed and constructed by Mr. C. G. Eden (formerly of the Laboratory), which has been worked constantly at temperatures exceeding 2,000 deg. C. for five months without even requiring the renewal of the carbon tube. Dr. Harker described this furnace in his lecture on High-Temperature Furnaces before the Faraday Society in March last, and we illustrated it on that occasion.*

British-Made Porcelain for Pyrometer Tubes.—Before the war porcelain tubes for pyrometer sheaths were largely of foreign manufacture, though the demand for them had grown enormously already before the war. Such porcelain must stand high temperature without deformation, and it must also stand sudden changes of temperature, for instance, when plunged into molten metal, and must be impermeable to the furnace gases, which would injure the platinum or alloy of platinum of the thermo-couple or resistance pyrometer in it. This latter property depends chiefly upon the nature and permanence of the glaze. In testing the permeability of the hard-paste porcelain of one British firm, the simple device illustrated in Fig. 6 has proved useful; exhaustion

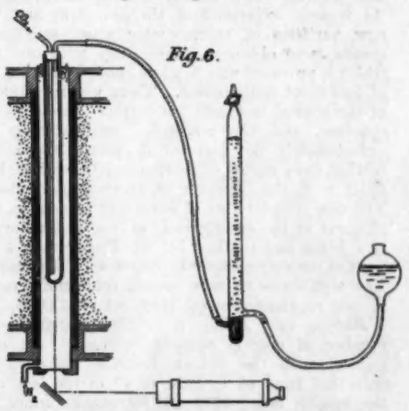


Fig. 6.

of the tube and analysis of the gases would be very troublesome and expose the tubes to unnecessarily high stresses. The tubes to be tested are usually closed below like test-tubes. The tube is placed within a vertical furnace, into which a test gas, generally hydrogen, is introduced, flushing the outside of the tube. Into the metal cap sealing the tube at the top another porcelain tube, of small bore, is fitted, through which a current of pure carbon dioxide gas is passed. The CO_2, leaving again, is sent into caustic potash solution which completely absorbs it; when the glaze of the hot tube under test begins to give way, however, hydrogen diffuses into the tube and is carried away with the CO_2, so that the escaping gas is no longer completely absorbed. The tube can be kept under observation by the aid of the mirror shown in the diagram. The behaviour of the new sheaths, compared with that of old approved tubes, has been encouraging.

Tungsten Arc Lamps.—The tungsten arcs of Messrs. Gimingham and Mullard, of the Edison-Swan Company, which we have noticed,† have been tested in special specimens, the hot electrodes of which are discs, about 8 mm. in diameter, not spheres, as in the commercial types. Owing to their having a source of light of considerable dimensions, these lamps appear to be an extremely useful source of radiation for optical pyrometer work, and apparatus have been constructed for applying this method, which promises to be expeditious.

* See ENGINEERING, vol. c., page 91.

* See ENGINEERING, March 17, 1916, page 260.

† See ENGINEERING, Dec. 3, 1915, page 675.

Thermometers (Messrs. Higgins and Hugo).—The noteworthy falling off during late years, and especially again last summer, in the number of thermometers submitted for testing calls for comment. As regards precision thermometers there was indeed a slight increase. But the numbers of meteorological thermometers were 8,016, 5,160, 3,465 in the years 1913, 1914, 1915; the decrease is chiefly due to "cold storage" thermometers, Class B, Kew, used on board ship, of which about 200, against 2,500, were submitted last year, probably owing to restricted shipbuilding. Again, clinical thermometers have gone down, the numbers for the years 1911, 1913, 1914, 1915 being 22,186, 19,400, 18,260, 16,137, and the average quality of the thermometers has decidedly deteriorated. Whilst formerly corrections of only 0.1 deg. and less were required by most instruments, many clinical thermometers now submitted are wrong by 0.3 and 0.4 deg., and fail to obtain the Kew certificate—the name "Kew" is retained, it will be remembered, although the testing is all done at Teddington. It is, moreover, known that the instruments submitted for test are in the majority of cases especially selected. The decreasing number cannot be attributed to the war, as the figures show; it is surprising, in fact, to read that, with one exception, no instruments were received for test on behalf of any of the official or unofficial military hospitals or institutions to the end of 1915. At the beginning of 1916 arrangements were made by the Navy for testing all their clinical thermometers, and samples have also been received from the Army Medical Supply Department. The report of the Laboratory cautions other organisations as to the purchase of untested clinical thermometers. As regards experimental thermometers and four new varieties of thermometer glass, satisfactory results were obtained, particularly with one type which is provided with a white enamel backing and of lens front construction. There was no tendency of the enamel to crack; but further investigation is required, and the respective manufacturers are unfortunately not inclined to pursue the matter further, because the Glass Research Committee have dealt with the question of thermometric glasses. The new complete set of secondary standards, constructed to the specification of the Laboratory, is now being standardised by Mr. Hugo, upon whom most of the thermometer-testing devolves at present. New certificates are now issued, conforming to the revised regulations of the Meteorological Office.

Radium and X-Ray Work (Mr. Higgins).—The number of radium samples submitted for comparison with the British Radium Standard has decreased from 63 in 1914 to 47 in the last year, the weights being 2070 and 930 milligrammes, and the approximate values 35,000*l.* and 14,000*l.*; these estimates represent the insurance values of the salts, which had decreased from 17 guineas to 14 guineas per milligramme of bromide. In addition to salts, 18 samples of radium luminous paint—consisting of zinc sulphide with 0.04 per cent. of radium bromide—have been tested by the γ-ray method. The Laboratory has also bought 5.19 milligrammes of pure radium bromide to serve as a substandard to step down to smaller quantities in testing; this sub-standard is convenient for the tests of luminous paints. The equipment has not been added to. As regards X-rays, the Council of the Röntgen Society has approached the Laboratory to co-operate in devising means for the protection of X-ray workers, especially by determining the absorption coefficient of the protective materials to be used. The equipment comprises a 16 in. coil a mercury-jet interrupter, and a selection of X-ray tubes, including a Coolidge tube with accessories and a Snook hydrogen tube; a new X-ray tube of the latter type was presented by Dr. Kaye, whose military duties keep him away from the Laboratory and from the radium section which he had started. The residual gas in the Snook tube is hydrogen, and the tube is provided with two "osmosis" pressure regulators of platinum or palladium. With the aid of the first regulator, which communicates with the atmosphere, hydrogen is withdrawn from the tube when the rays are to be hardened; the other regulator, which is raised to a white heat by sparking, communicates with an auxiliary bulb, charged with hydrogen, so that hydrogen can diffuse into the tube proper to soften the rays. The anti-cathode is a plate of tungsten in a massive support of copper.

Metrology (Messrs. J. E. Sears, M.A., S. W. Attwell, H. L. P. Jolly (on active service), E. A. Owen, E. G. Constable, F. H. Rolt, F. A. Gould, V. Stott, B. P. Dudding, H. A. Dear, J. K. Enock, and thirty-one temporary assistants, including volunteers). *Gauges, Screw-Gauges, Sparking-Plugs; Aneroids. Taximeters. Watches. Réseau Ruling.*—The largely increased staff sufficiently indicates that there was a heavy burden of special work, particularly for the Ministry of Munitions. Though other members of the Laboratory staff, under the leadership of Messrs. Paterson and Kinnes, helped on evening shifts, and commercial testing fell below the normal—except in engineers' gauges and aneroid barometers—most of the researches concerning the silica metre, re-determination of the 4-metre bar and Hartmann end gauges, prime standard barometers, and calibration of new standard barometers, &c., had to be suspended. As regards screw-gauges, the division has recently issued a pamphlet of considerable utility to manufacturers. At the instigation of the Engineering Standards Committee an investigation has been commenced into the sizes of commercial sparking-plugs and tapped holes for motor engines; difficulty having been experienced in securing interchangeability between sparking-plugs and engines of English, Continental and American makes, it was desired to ascertain whether the standard recently laid down by the Committee really represented current practice. For this purpose a number of sparking-plugs have been obtained commercially and been tried, together with a screw plug gauge (E.S.C. standard), into a number of engines on the premises of various firms visited. The investigation is not yet completed. The ruling of a réseau plate for star photography was tried on the Blythswood machine, as the source of supply for such plates is cut off. The machine was modified for the purpose, but the ruling on the silver film was not as clean and uniform as was desired; there was a slight variability in the thickness of the lines, which affected one edge of a line more than the other. Owing to pressure of other work further plates were not ruled.

A large proportion of the watches to be tested come from Switzerland, and the imposition of a customs duty on watches caused some difficulties, until an arrangement was made by the intervention of Sir Lawrence Guillemard, Chairman of the Board of Excise and Customs, for the admission of such watches free of duty and without customs examination, the Laboratory undertaking to re-export the watches within three months of the date of receipt. As the Laboratory test is valued by the Swiss manufacturers, the arrangement suits all the parties concerned. The imposition of a duty (33⅓ per cent. *ad valorem*) on movements imported has, however, reduced the number of Class A trials, while the number of entries of all watches was 379, against 357 in 1914-15. On the other hand, only 14 (against 19 in 1914 and 37 in 1913) watches obtained 90 marks and more, and 52 Class A watches were awarded "especially good," against 87 in 1914. Thus the "especially good" percentage, which had gone up to 68 in 1913 and to 70.7 in 1914, is now down to 58.4 per cent. Of the total number of watches submitted, 379, as many as 56 failed to obtain the desired certificate; the tests distinguish the classes: Class A, Class B, Police, Subsidiary A, Subsidiary Police, Special (military). The report gives test results of the 50 best watches; the firm of Messrs. Vacheron and Constantin leads with 95.7 marks (highest record since 1912), and the first 11 watches were all Swiss. Of 87 marine chronometers submitted, 33 failed; this percentage of 39 is above the average of the past 10 years.

Optics (Messrs. T. Smith, B.A., R. W. Cheshire, J. Guild, J. S. Anderson, R. J. Trump, D. W. H. Bell, Miss A. B. Dale and Miss C. N. Jones).—Nearly all the work done has been in connection with the war, for the Admiralty, and later also testing binoculars and telescopes in large numbers for the Ministry of Munitions; the numbers of tests made by the division in 1913, 1914 and 1915 were 7,846, 10,579, 19,542. A special staff had to be trained, and as the instruments arrived earlier than anticipated, re-arrangements were required for testing nearly 4,000 instruments within a few weeks; it is acknowledged that the work was thoroughly well done. This rush then stopped, but other heavy work continued, and the numbers above stated do not include special instruments for the Ministry of Munitions. The Division also assisted the Admiralty in preparing a book of instructions on the correct use of telescopic sights and other instruments for gun-layers, and tested new sextants made to the designs of the Laboratory.

Optical Glasses; Navigation Lights; Cemented Objectives.—Research work was continued in spite of all the difficulties. In testing optical glasses by the aid of the bright hydrogen lines, the hydrogen tubes were found to deteriorate rapidly. Mr. Guild observed that the electrodes evolved hydrogen, causing a rise of gas pressure in the tube; he sealed a large auxiliary tube to the discharge tube, of about a hundred times the capacity of the discharge tube, and he thus prolonged the life of the latter nearly a hundred-fold. Gaseous impurities in these tubes are of little importance, provided mercury be absent; oil pumps, not mercury pumps, should therefore be used. Among tests of special interest were those of a photographic shutter examined for efficiency at various inclinations; as the testing apparatus is necessarily kept horizontal, systems of mirrors had to be added. Accounts of some of the special researches have only quite recently been brought by Mr. T. Smith before the Physical Society. The first of these, a paper on "Lenses for Light Distribution," concerned lenses for ship navigation lights and motor-car head-lights. Ship lights ought to give a beam of uniform intensity, in spite of the rolling of the ship, over an angle between 5 deg. of elevation and 5 deg. of depression, and have the same light distribution for all azimuths. The old lamps were very imperfect in these respects, and when the Board of Trade asked the Laboratory to investigate these problems, the optical side, the design of suitable lenses, fell on Mr. Smith, while Messrs. Paterson and Dudding dealt with the visibility problems. The complex lenses of Mr. Smith, which give very satisfactory results, are moulded and then glazed in some cases; they do not require optical finish. The curves to be used in making cemented telescope objectives with the standard glasses of Messrs. Chance and special glasses have been issued in pamphlet form and tables; and Mr. J. Smith has read a paper on the "Choice of Glass for Cemented Objectives" before the Physical Society, and a further paper on the "Correction of Chromatic Aberration when the External Media are Dispersive." Further tables showing the results of tracing rays trigonometrically through the various objectives, which number between two and three hundred, and tables on means of interpolating when the glasses to be employed differ somewhat from the standard glasses, for which the first tables give the curves, are shortly to be published. The note by Mr. Guild on the "Use of the Auto-Collimating Telescope in the Measurement of Angles," also communicated to the Physical Society, draws attention to certain sources of error in some methods of angle determination.

Tide Prediction (Mr. F. J. Selby, M.A., Mr. W. H. H. Brookes).—At the end of 1915 Miss Rudkin was appointed to take the place of Mr. Bell, who is now, like Mr. J. Brookes (who assisted in this Division), on active service. The work had fallen into arrears, but good progress has been made with the tables for 1918. The predictions for Port Brisbane are continued, and tables are being prepared for Koh Hlak, an island off the coast of Siam, on behalf of the Siamese Army Survey. The tide constants from Koh Hlak, communicated to Teddington, are interesting; the semi-diurnal components are relatively very small, and there is practically only one high water and one low water in every 24 hours throughout the year. The Division has also advised as to the construction of a tide-predicting machine by Messrs. Kelvin, Bottomley and Baird for the Argentine Government. The experience gained in 1913, when such a machine was built for the Japanese Hydrographic Office, is valuable; 18 components are to be concluded, and in the selection of these data from ports all over the world are being examined.

Library (Mr. R. A. Frazer, B.A.).—Mr. Frazer was appointed Librarian in 1914, when the books were transferred to the new buildings. Mr. Selby

had so far acted as Librarian in addition to his onerous duties as Secretary of the Laboratory. A catalogue is being prepared; there will be a separate author's card index for the hundreds of pamphlets, classified as to subjects, and reference cards have been introduced advising members of the staff immediately of new publications likely to interest them.

FISHGUARD HARBOUR WORKS.

ONE of the outstanding events in the management of the Great Western Railway by the late Sir James Inglis was the construction of the Fishguard Harbour in North Pembrokeshire and the establishment of a fast service, by means of high-speed turbine steamers,* with Rosslare, in Ireland, forming thus a connection between the Great Western Railway on this side of the Irish Channel and the Great Southern and Western Railway of Ireland on the other. Sir James Inglis, after leading a most active life both as engineer and railway manager, died in December, 1911, before the completion of the works above referred to. On his decease the firm of Messrs. Coode, Matthews, Fitzmaurice and Wilson were asked to examine the undertaking at Fishguard and to report thereon, with a view to their advising the Great Western Railway Company as to the extent and character of the works which, in their opinion, were necessary to complete the project. This duty they the more readily undertook in view of the friendship which had so long existed between the late Sir James Inglis and their firm.

The original object of the establishment of a harbour at Fishguard was the accommodation of the cross-Channel steamboat service to and from Ireland to which we have just alluded, and there can be no doubt that with that object in view the design of the harbour and the works in connection therewith were well conceived. The depth in the harbour in front of the cross-Channel steamer quay and the new railway station, as shown in the plan, Fig. 1, is fully 20 ft. at low water of spring tides, which tides rise 13 ft. 6 in. This is amply sufficient for the traffic carried on there. Nor does there appear to have been any material loss of depth by shoaling over the enclosed area, notwithstanding that the depth over a portion of the sea-bed sheltered by the works executed under Sir James Inglis's direction has been materially increased by dredging.

It appears that the breakwater originally proposed to protect the northern boundary of the harbour was, in accordance with the powers granted by the Act of 1893 to the Fishguard Railway and Pier Company, to be 1000 ft. long, constructed on a curved line, and consisting of external walls formed of concrete blocks, filled between with rubble hearting. Subsequently this mode of construction was abandoned and a rubble mound substituted in lieu thereof, the concrete blocks which had been made, but not set, being afterwards utilised in the Irish quay. The breakwater mound consists of rubble of all sizes as obtained from adjacent quarries, having a sea slope, for a thickness of about 20 ft., composed of the largest selected stones, varying from 25 tons down to 5 tons. The width of the top of the mound was 70 ft. Latterly, however, the quarries failed to supply an adequate quantity of large stone suitable for depositing in the mound.

In November, 1903, the breakwater had reached the 1000-ft. length originally proposed; but in the meantime, in 1899, an Act had been obtained for the prolongation of the work to a point 2250 ft. from land, so that, on the completion of the 1000-ft. length, the extension was carried on continuously, and was completed in the summer of 1906, when the cross-Channel service was opened. It was subsequently considered advisable, however, to extend still further the breakwater, in order to provide increased protection for the cross-Channel steamers when lying alongside the Irish quay. Powers were therefore obtained, in 1908, for a further extension, and again in 1914, ultimately making a total length sanctioned of about 3000 ft. After the work had been in hand for some time it was found that the northerly and north-easterly gales, which produced the heaviest seas experienced at Fishguard, were causing large quantities of rubble to be driven around the end of the breakwater, lodging as salient accumulations on the harbour side. With a view to prevent this action and minimise the wastage of material arising therefrom, a concrete core was provided, extending outwards from the lighthouse, which was temporarily erected at 1800 ft. from the shore end of the breakwater. The provision of this core of concrete has been attended with satisfactory results, as shielding the rubble from the full action of the sea-stroke during gales. A sheltering parapet is also being constructed throughout the whole length of the breakwater, the landward portion of it being founded upon the rubble mound at a level of 10 ft. above high water; whilst from the lighthouse outwards, where the concrete core is available, the foundation of the parapet rests upon it. This core is shown as part of the section, Fig. 2, page 6, illustrating the work as now being finally completed.

In January, 1911, on the occurrence of a heavy northerly gale, considerable damage was done to the seaward face of the breakwater, the toe of the slope at and about low-water level being much disturbed and certain portions of it extensively undermined.

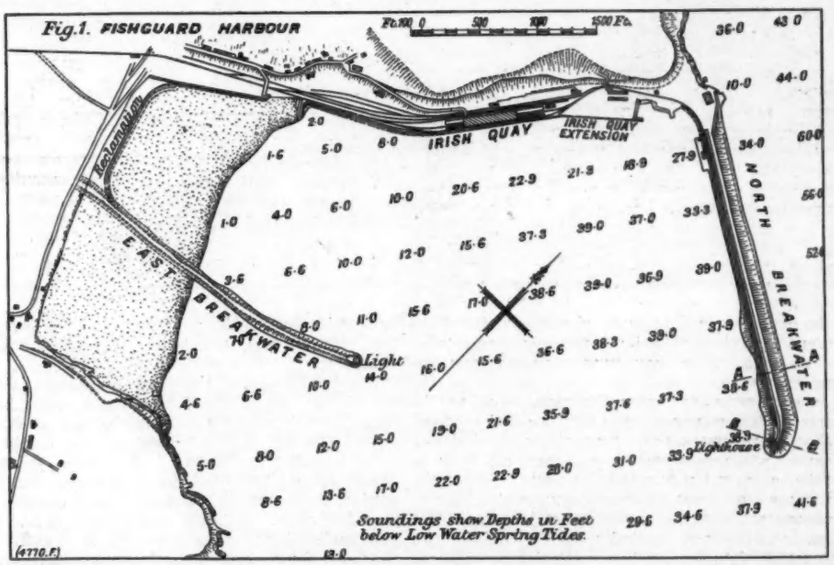
At the time the works were devised by Sir James Inglis there was no idea that the port would be frequented by liners, or that accommodation for vessels of this last-named class would be required, such suggestions having grown up as the works progressed and developed. In August, 1909, however, arrangements were made with the Cunard Company for their liners to call at Fishguard on the homeward journey from America for the purpose of disembarking passengers, and consideration was then given to the question of the construction of an ocean quay on the harbour side of the north breakwater. Various proposals with regard to the design of this last-named work were discussed, although no definite decision was arrived at with respect thereto.

We give in Fig. 1, annexed, a plan showing the north breakwater, which mainly protects the harbour of Fishguard; the Irish quay, which, as we have stated, is well adapted for the convenient carrying on of cross-Channel traffic to Ireland; and the east breakwater, which it was intended to prolong further seaward, but which for the present is curtailed at the point indicated on the plan. We likewise give on page 6 two cross-sections of the north breakwater as now being completed. This structure is exposed to an abnormally heavy sea, almost of Atlantic force, during the occurrence of northerly and north-easterly gales, and sometimes after heavy south-westerly storms, when the wind, veering to the north, sets shoreward a sea of unusual violence. One section, Fig. 2, is through the outer part of the breakwater, and the other, Fig. 3, is at the head where the lighthouse is to be erected.

It will be observed from the section, Fig. 2, that the depth along the line of the sea-bed, as it originally existed before the construction of the breakwater, varied from 38 ft. to 44 ft. at low water; and that to form the requisite slopes, especially on the seaward side, necessary to ensure the permanence of the work, a mound approaching 400 ft. in width at the base has been necessary. At the time of Sir James Inglis's death the mound of the north breakwater had been completed for the width marked as the original rubble mound, and indicated by cross-edging. It will be apparent from the sections that considerable quantities of rubble had still to be deposited below low-water level in order to form the mound to the required ultimate angle of repose to prevent subsequent disturbance by wave action, particularly in such an exposed position. If the transportation of this rubble from where it had been tipped to where it was required in the mound had been left to be performed by sea action alone, many years would have expired before the feeding of the slope by degrees, which is alone practicable by this process, would produce the ultimate permanent slopes necessary. By the adoption of the mode of procedure now being carried out, however—viz., by the deposit from hopper barges of rubble, arranged as shown on the cross-sections, and tipped to the slopes shown—the angle of repose, which would otherwise have been formed by sea action and have required many years for accomplishment, is now attained step by step as the work advances seaward, from the shore end of the breakwater outwards.

Again, in order to cope with the heavy seas during gales to which we have alluded, from low water upwards the new sea face of the breakwater in course of construction consists of pell-mell concrete blocks, each of 40 tons weight, the idea being that as these blocks are placed in an irregular form, the force of the seas falling on to them is broken to a considerable extent by absorption into the interstices between the blocks, which practically amount to one-third of the entire cube of the mass. The result is that, in consequence of these interstices and the innumerable salient angles of the blocks presented to the oncoming seas, the waves are broken up, so that their force is effectually diminished.

The photographs reproduced on Plate I., published this week, illustrate the mode of construction which is now being adopted, and show clearly the character of the face which is being made to the breakwater, more particularly with respect to the pell-mell blocks to which we have just referred. Of course, the considerable addition to the mound under water, which entails the deposit of a vast quantity of material, is not visible, being beneath



* See ENGINEERING, vol. lxxxii., page 106.

FISHGUARD HARBOUR WORKS; THE CONSTRUCTION OF THE NORTH BREAKWATER.

MESSRS. COODE, MATTHEWS, FITZMAURICE, AND WILSON, ENGINEERS; MESSRS. TOPHAM, JONES, AND RAILTON, CONTRACTORS.

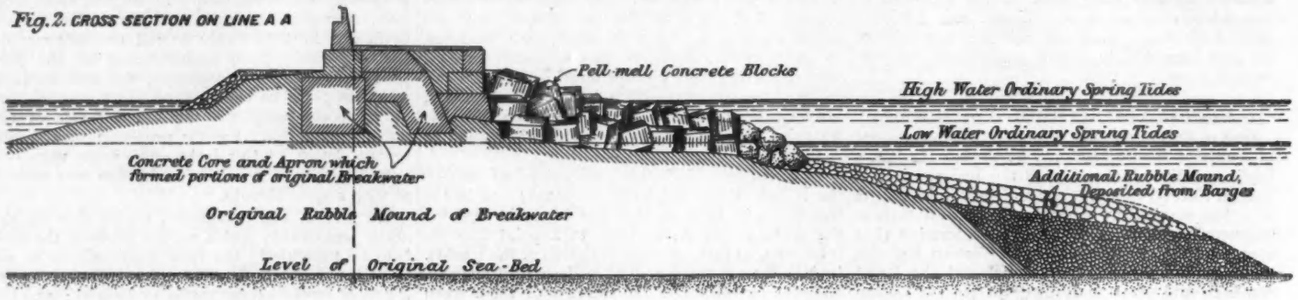


Fig. 2. CROSS SECTION ON LINE A A
Pell-mell Concrete Blocks
High Water Ordinary Spring Tides
Low Water Ordinary Spring Tides
Concrete Core and Apron which formed portions of original Breakwater
Additional Rubble Mound, Deposited from Barges
Original Rubble Mound of Breakwater
Level of Original Sea-Bed

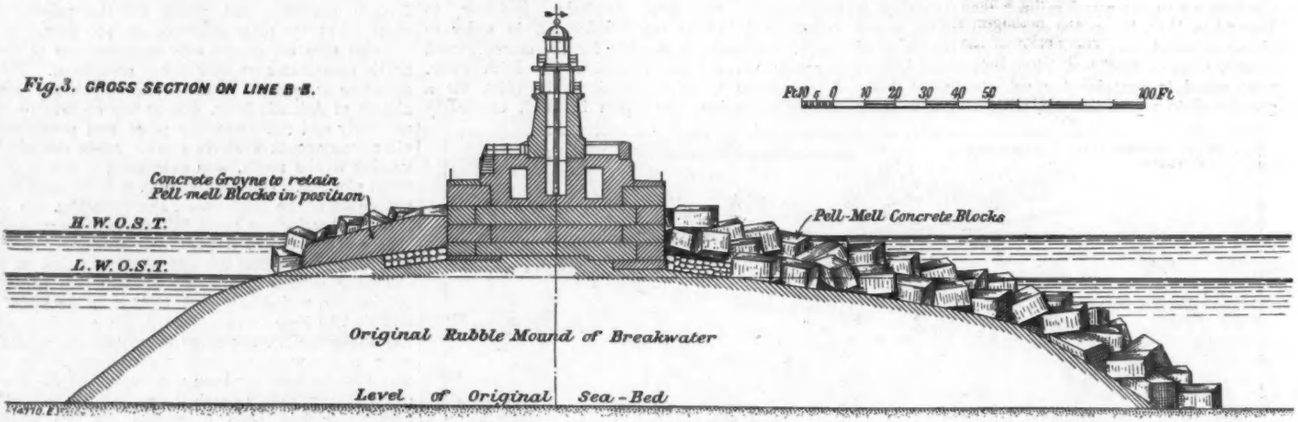


Fig. 3. CROSS SECTION ON LINE B B.
Scale 0 10 20 30 40 50 100 Ft
Concrete Groyne to retain Pell-mell Blocks in position
H.W.O.S.T.
L.W.O.S.T.
Pell-Mell Concrete Blocks
Original Rubble Mound of Breakwater
Level of Original Sea-Bed

low-water level. The superstructure of the breakwater proper is being strengthened and added to throughout the entire length of the breakwater by the carrying out of the work shown by cross-lines on the sections, Figs. 2 and 3, above.

The rock for the additional rubble mound is blasted from the quarry to the north-west of the root, or shore end, of the breakwater and seen in the foreground of Fig. 5, on Plate I., and is conveyed in trays on railway wagons to, and lowered into the barges by cranes from, the temporary wharf on the harbour side of the breakwater, as seen in the distance in the view, Fig. 4, Plate I.

The barges are towed to the position over the rubble mound marked by buoys, and there the rubble is dropped into place. The barges used have a capacity of about 120 tons and are fitted with hopper doors operated by chains working on winches actuated by hand rack-gear. In the view, Fig. 7, on Plate I., a barge is to be seen depositing the rubble in the sea. From time to time soundings are made to ascertain whether and where there are any inequalities in the slope of the mound, and these are made good by subsequent dumping. The sizes of the rubble deposited by barges range up to pieces weighing 7 tons.

The concrete blocks for the pell-mell work, for increasing the height of the breakwater and broadening and making a higher sea face, as shown in the section, Fig. 2, on the present page, are made in a block-yard, illustrated in Fig. 6, on Plate I. The proportions are 6 of crushed rock and sand from Fleetwood to 1 of Portland cement. The rock, after being washed, is crushed to pass a 1½-in. mesh by four Marsden machines, and elevated into bins. The concrete mixer is seen beyond the Goliath crane in the view, Fig. 6, on Plate I.

The lay-out of the plant is conducive to rapidity and economy in labour. A loop line for the cubic-yard wagons is formed with the concrete-mixer at one end, and the cement store and measuring hopper at the other, while on one side of the loop are the sand-shoots, and on the other the ballast-crushers and shoots. The mixer has a double elevator for raising two wagon-loads, so that the contents may be deposited in either one of the compartments of the hopper over the mixer; the other units of the plant have elevators suitable for the material to be dealt with. The empty wagon passes from the mixer first to receive the sand, next to get the cement, returning under the stone-shoot to the mixer. The arrangement of the door of the ballast-shoot is noteworthy: instead of the usual sliding cover, which occasionally gets jammed, there is fitted a curved tray which is rocked clear of the shoot by a lever, an arrangement which ensures closure without the possibility of jamming. The mixer in use is of the Smith double conical type, and the minimum number of rotations is eighteen.

The concrete when mixed is discharged into cubic-yard side-tip wagons, which pass over railway tracks with turntables laid on staging at the height corresponding to the top of the block moulds, as shown in Fig. 6, on Plate I. Two sizes of blocks are made for pell-mell work: one of 30 tons weight, having dimensions 10 ft. by 8 ft. by 6 ft., for deposit from barges below low-water level, as shown in Fig. 2; the other of 40 tons weight, having dimensions 12 ft. by 7 ft. by 7 ft., for deposit by Titan crane above low-water level. The moulds are built up of timber, as illustrated, and the inside walls are tarred and coated with soap oil, while the bottom has a dusting of sand. The moulds are removed from the concrete in three to five days, according to weather and season, and ultimately, by means of lewis bars with T-headed bolts fitted in cavities arranged for in casting the blocks, are, after a minimum period of seven days, lifted and stacked by the Goliath crane in order to mature; the period of three months being allowed to elapse before they are considered ready to be set. On being taken to the breakwater on the special block wagons, the Titan crane, well shown in Fig. 7, carefully deposits the blocks in pell-mell formation, in order to achieve the end already referred to, and admirably shown as accomplished in the view, Fig. 7. The crane, which has the remarkable radius of 125 ft., was built by Messrs. Stothert and Pitt, Limited, Bath, and we hope to illustrate it separately in a later issue. The blocks forming the increased high and new face are similarly constructed and deposited in position. The backing or interior behind the new faces and the parapet are built *in situ*, the latter, of course, within shuttering.

The total length of this north breakwater, when completed, will be about 3000 ft., a round head being formed at its seaward termination, as shown on the plan, Fig. 1, and the section, Fig. 3, above. It is intended to "return" the 40-ton pell-mell blocks around the head in accordance with the section, three spurs or short groynes of concrete in mass being provided in the manner indicated on the plan and section, in order to prevent the "swirl" of the sea at the extreme end of the work from carrying the blocks by degrees, during gales around the end, in the same manner as the rubble-stone has been carried, as seen beyond the temporary wharf in Fig. 4. This swirl has resulted in the formation of the spit on which the head will be constructed. In order also to prevent the disturbance of the rubble under water at the extreme end of the work, the pell-mell block system will be carried downwards from low water to the sea-bed, as shown on the cross-section, Fig. 3.

In connection with the works which have been already executed we may observe that during a heavy gale which occurred on November 12 last, and which was really the first severe trial to which the new works had been subjected, only one of the pell-mell blocks was moved, and that in a somewhat interesting manner. The block we refer to, which weighed 40 tons, was lifted bodily and deposited by the sea on the top of an adjacent block 7 ft. 6 in. higher than its original position. Neither the block that was moved nor the block on which it was deposited was damaged. This is an indication of the excessive wave-force to which the new sea-face is exposed; but having regard to the arrangement of the blocks, the extent of the interstices and the slopes which have been adopted, the undertaking, as it is now being carried out, is answering the purpose for which it was devised with remarkable success.

In connection with the sheltering works described at the north breakwater an extension of the Irish quay, for the additional accommodation of the cross-Channel service, is shown also on the plan,

TRIPLE-TURRET HIGH-SPEED VERTICAL TURNING AND BORING MILL.

CONSTRUCTED BY MESSRS. G. WILKINSON AND SONS, ENGINEERS, KEIGHLEY.

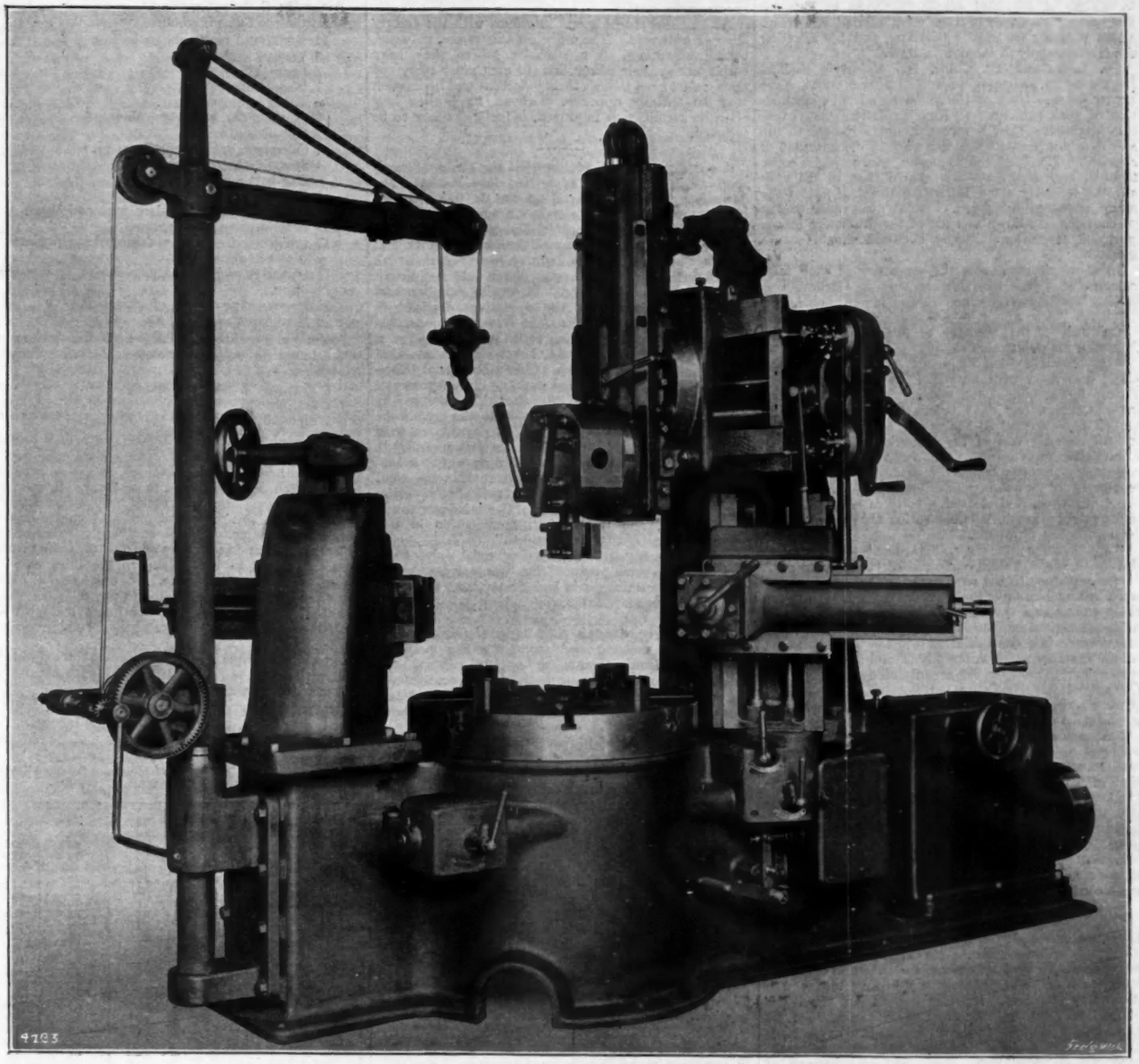


Fig. 1. This work, built up of concrete blocks, is well advanced, and, when completed, will afford useful additional berthage at this spot for cross-Channel traffic and for the laying up of vessels whilst being overhauled.

The contract for these works was let to the well-known firm of Messrs. Topham, Jones and Railton, Limited, in July, 1913, Mr. L. G. Felkin, M.Inst.C.E., being their agent in charge. The date for their completion is April 1, 1917; but in consequence of delays due to the war and difficulties which have occurred in maintaining the necessary labour staff, it is probable that this date will be exceeded. The engineers are Messrs. Coode, Matthews, Fitzmaurice and Wilson, MM.Inst.C.E., their resident engineer at Fishguard being Mr. G. Lambert Gibson, M. Inst. C.E., who was also Sir James Inglis's local representative during his direction of the works.

TRIPLE-TURRET HIGH-SPEED VERTICAL TURNING AND BORING MILL.

On this page we illustrate a triple-turret high-speed vertical turning and boring mill by Messrs. G. Wilkinson and Sons, Bradford-Road Tool Works, Keighley. It will be seen that there are three tools which can be all at work at the same time, and that one of these is carried on a turret head, which is fitted with four tool-holders. This is provided with a spring plunger and lever for fixing its position true with its own slide, and has both vertical and horizontal self-acting feed. There are six variations of positive feed, which can be changed instantly by a handle. The other tool-holders are on compound slide-rests moving on stiff vertical box standards firmly bolted to the main body on either side of the table. These tools have hand and self-acting feeds, and can be stopped and reversed as desired. The table has both T slots and four chuck-jaws, and is supported on its underside by a true surface. All the self-acting motions are driven through one gear-box by machine-cut gearing. The machine is made in two sizes to admit work 2 ft. 6 in. in diameter by 1 ft. 9 in. high and 3 ft. in diameter by 2 ft. high. The particular machine illustrated is shown fitted with a crane for handling the work.

THE DUTCH NAVY.—According to the *Rivista Marittima*, two 7,000-ton, 30-knot light cruisers are in course of construction, one in Amsterdam and one in Flushing; they are to be armed with ten 152 mm. (6-in.) guns. Four submarines are also being built, three in Rotterdam and one in Flushing; these are 836-ton boats and will have a speed of 17.5 knots on the surface.

THE SOCIETY OF BRITISH AIRCRAFT CONSTRUCTORS.—The first ordinary general meeting of the Society of British Aircraft Constructors, Limited, was held at the Hotel Cecil, on Friday, June 23 last, the chairman of the Society, Mr. H. White Smith, presiding. The representatives of nearly all the members of the Society were present. The chairman said that all the British companies and firms constructing aircraft, and practically all those constructing aero-engines, had become ordinary members of the Society. In addition, several firms engaged in the manufacture of important accessories, including the propeller-making firms, had been elected to associate membership. The Committee of Management, which was appointed at the last meeting of the Council to conduct the general business of the Society, had held fortnightly meetings and a considerable amount of business had been done. He would instance, in particular, the important subject of excess profits both in connection with the Finance Act of last year and the Finance Bill of the present Session, and the negotiations which were taking place with the Ministry of Munitions. All Government departments concerned had been notified of the incorporation of the Society, and it was recognised that the Society was the representative body to look to on any question affecting the aircraft industry.

INDUSTRIAL NOTES.

THE attention of the Minister of Munitions has been drawn to the fact that persistent rumours, possibly of enemy origin, are in circulation as to the danger to the life of men and women employed at National Shell-filling Factories of the work carried out there. These rumours are most misleading, and are affecting the labour supply at the new factories.

Dr. Legge and Dr. Collis, His Majesty's Medical Inspectors at Factories under the Home Office, have authorised the issue of the following official contradiction of such rumours:—"High explosives may cause skin irritation; this, however, is not a danger to life and does not persist when the work is discontinued or changed. T.N.T. is the explosive which might cause trouble, but experience has shown that it has only affected seriously a few isolated individuals out of the many thousand employed. Strict observance of the precautions laid down and use of the protective means provided at National Filling Factories should ensure safety."

In these circumstances the spreading of such false rumours at a time like this can only be attributed to sinister and unpatriotic motives and is punishable.

On July 2 the Ministry of Munitions issued the following for publication:—

"On Monday, June 26, about 5,500 engineers and allied tradesmen went on strike at Vickers, Limited, Barrow-in-Furness. The reason alleged was the introduction a few days before of diluted labour on skilled men's work. At Vickers the question of dilution up till recently was in the hands of a Joint Trades Committee representing the various trade unions concerned. Shortly before the strike the men took the matter out of its hands, refused any longer to recognise the Committee, and elected a body of shop delegates in its place, who took up the position that there should be no dilution of labour.

"Mr. Lynden Macassey, K.C., went to Barrow to deal with the situation on behalf of the Government. It was explained to the men on strike that their ceasing work was a violation of the Treasury Agreement between their unions and the Government, and also a breach of the Munitions of War Act, 1915. The Government's intention to introduce dilution into the Barrow district on the same terms as on the Clyde and the Tyne was made clear. The strike was repudiated by the Executive Council of the Amalgamated Society of Engineers. After a series of mass meetings the men decided by a majority on a ballot not to resume work.

"A notice was then published giving the men 48 hours to return to work, expiring at 6 p.m. on July 1, with an intimation that failing by that time a resumption of work, proceedings would be taken under the Defence of the Realm Act against those who instigated the strike, and under the Munitions of War Acts against those others who took part in the strike. All picketing was prevented and public houses were closed."

At 5.30 p.m. on July 1 there was a general resumption of work, and dilution has proceeded in Barrow under the same conditions as elsewhere.

The Secretary of the Admiralty makes the following announcement under date July 2:—

"In accordance with an arrangement entered into with the Ministry of Munitions under Section 20 of the Munitions of War (Amendment) Act, 1916, the Admiralty have issued an order applying the provisions of Section 7 of the Munitions of War Act, 1915, as amended by Section 5 of the Munitions of War (Amendment) Act, 1916, to all establishments engaged in the construction, alteration, repair or maintenance of docks and harbours and works in estuaries."

Section 7 of the 1915 Act prohibits the employment of persons who have left work in munitions factories; Section 20 of the Amendment Act, 1916, deals with extensions to other departments; and Section 5 of the Amendment Act, 1916, covers the procedure to be followed by the employer when a workman is dismissed or discharged.

Labour union officials, says the *Marine Journal*, New York, who are always seeking trouble, so as to make the necessity of their employment apparent, are evidently getting ready to put the screws to the shipyards of the United States now booming with industry. Several incipient strikes with resultant loss of valuable time to employers and employees have already been reported in spite of the fact that wages since the beginning of the war have been advanced in all the yards an average of 40 per cent. Practically all the skilled workers are employed on a piece basis, the riveters, who are regarded as most important, receiving from 5 dols. to 6 dols. a day. So far, no labour difficulties that might be termed strikes have been reported at the yards of Harlan and Hollingsworth Corporation, Wilmington, Del., the Fore River Shipbuilding Company, Quincy, Mass., or the Newport News Shipbuilding Company, but a strike was in progress a few weeks ago at the New York Shipbuilding Company's yard in Camden, causing principally a shortage in riveters, and another large Atlantic Coast yard also had a strike which delayed work from 30 to 40 days; and there is no certainty that the trouble has been permanently settled.

All this is disturbing and interferes with the acceptance of contracts. The union organisers are, as usual, taking advantage of a situation where they have employers at their mercy, and the men must carry out their orders even though their judgment and inclination may be entirely opposite. Labour, no matter how often its condition is improved, is inclined never to be satisfied.

According to the *Yorkshire Post* the strike of woolcombers in Bradford was settled last Friday. The operatives sent in a demand for the 2*s.* war bonus to be converted into a 5*s.* permanent advance in wages. The Woolcombing Employers' Federation offered, by way of compromise, an immediate advance of 1*s.* and a further advance of 1*s.* in January next, together with the conversion of the 2*s.* war bonus into a "time" bonus, to be paid conditional on regular attendance at work. This compromise the operatives declined to accept, and they commenced to come out on strike. Further negotiations proving futile, representatives of both parties were summoned to London for an interview with Sir George Askwith, Chief Industrial Commissioner, who recommended that the draft agreement embodying the employers' offer should be accepted by both parties, with the exception that the second 1*s.* offered by the employers should be payable as from September 8, 1916, instead of on the first pay day in January next. Also that the following words should be added to the agreement:—"Save that, in the event of a further material increase in food prices, both parties should refer to the Chief Industrial Commissioner to say whether any, and if so what, modification in this agreement is necessary and justified."

This agreement is to be binding until July, 1917. The proposals were accepted by both employers and employed at meetings held last Friday, and work was resumed on Monday last.

The quarterly ascertainment under the Cumberland sliding scale showing the average selling price of hematite pig-iron warrants to be 115*s.* per ton, the blastfurnacemen's wages are now 93¾ per cent. above the standard. For the corresponding quarter of last year their wages were 68¾ per cent. above the standard.

Another increase of 3½ per cent. has been granted to the miners of the Black Country (South Staffordshire and East Worcestershire). It represents an increase of 3*d.* per day for pitmen, 2*d.* a day for loaders, and 1½*d.* per day for surface men. The pitmen's wages now exceed 9*s.* per day, the loaders' 7*s.*, and the wages of the surface men 5*s.* 6*d.* per day. Such high figures have never before been reached in the mining trade; compared with the 1888 rates, the wages now paid show an advance of about 100 per cent.

The Minister of Munitions has made further Orders under the Munitions of War Acts, 1915 and 1916, under which 339 additional establishments have been declared controlled establishments. The total number of Controlled Establishments is now 3,916.

THE WORKING OF THE BOILER EXPLOSIONS ACTS.

THE annual report for the year ended June 30, 1915, on the working of the Boiler Explosions Acts, 1882 and 1890, has just been issued by the Board of Trade. During the period named, 57 preliminary inquiries and 3 formal investigations were held under the provisions of the Acts. The 61 explosions thus dealt with caused the deaths of 22 persons and injury to 55 others. The 22 deaths were caused by 8 explosions, of which 5 occurred on land and 3 on ships. Fifteen of these deaths were caused by two explosions, one from a vertical "Rastrick" boiler on land, and the other from a steam pipe on board a ship. The numbers of persons killed and injured are below the general averages (26.2 and 58.5) for the 33 years since the Act of 1882 came into force, and it is satisfactory to be able to record a drop in the number of explosions which occurred during the year, which is below the average (72.4).

In one case the Commissioners made an important recommendation to the effect that boiler insurance companies should arrange as far as possible to vary the districts assigned to their inspectors, and that there should be a more careful supervision in the passing of the inspectors' reports, and in the issue, upon such reports, of certificates of fitness for a given working pressure.

On analysis of Appendix A, which gives a summary of the explosions, it appears that 16 boilers, &c., were under boiler insurance companies, 6 were under mutual marine insurance companies, 4 were under Lloyd's Register and Lloyd's underwriters, 1 was under the British Corporation and Lloyds, and the remaining 34 were not inspected or insured by any company or association.

Appendix B describes the 61 explosions as having arisen from the following boilers, vessels, &c.:—

11 Horizontal multitubular boilers.
3 Vertical boilers.
2 Lancashire boilers.
7 Water-tube boilers.
4 Tubes in steam ovens.
9 Steam pipes, stop-valve chests, &c.
2 Hot-plates, &c.
4 Calenders, drying cylinders, &c.
4 Steam-jacketed pans.
6 Rag-boilers, kiers, stills, &c.
9 Miscellaneous.

The causes of the 61 explosions were as follow:

17 Deterioration or corrosion.
12 Defective design or undue working pressure.
6 Water-hammer action.
11 Defective workmanship, material, or construction.
11 Ignorance or neglect of attendants.
4 Miscellaneous.

Appendix C states that the 3 explosions respecting which formal investigations were held during the year related to:—

1 Vertical "Rastrick" boiler.
1 Marine boiler.
1 Lancashire boiler.

These explosions resulted in the death of 9 persons and injuries to 22 others. The causes, the report states, had been clearly ascertained, and in no case has the explosion been attributed to accident. In one case a company's engineer was found responsible for the explosion and two boiler tenters and engine-drivers were held to blame. In a second case the user of the boiler, an insurance company and one of their inspectors were found to blame, and in the third case no person was found to blame. In one case a boiler insurance company were ordered to pay 80*l.*, the boiler user 15*l.*, and the insurance company's inspector 5*l.* towards the costs and expenses of the formal investigation.

Appendix D gives the total number of explosions dealt with since the passing of the Acts, the number of lives lost, and persons injured:—

Year.	Number of Explosions.	Personal Injuries.		
		Number of Lives Lost.	Number of Persons Injured.	Total.
1882–83	45	35	33	68
1883–84	41	18	62	80
1884–85	43	40	62	102
1885–86	57	33	79	112
1886–87	37	24	44	68
1887–88	61	31	52	83
1888–89	67	33	79	112
1889–90	77	21	76	97
1890–91	72	32	61	93
1891–92	88	23	82	105
1892–93	72	20	37	57
1893–94	104	24	54	78
1894–95	114	43	85	128
1895–96	79	25	48	73
1896–97	80	27	75	102
1897–98	84	37	46	83
1898–99	68	36	67	103
1899–1900	59	24	65	89
1900–1	72	33	60	93
1901–2	68	30	55	85
1902–3	69	22	67	89
1903–4	60	19	45	64
1904–5	57	14	40	54
1905–6	54	25	21	46
1906–7	77	28	65	93
1907–8	73	23	50	73
1908–9	93	12	53	65
1909–10	103	14	62	76
1910–11	100	13	61	74
1911–12	106	30	75	105
1912–13	80	31	42	73
1913–14	68	22	74	96
1914–15	61	22	55	77
Totals ..	2,389	864	1,932	2,796
Average of 33 years ..	72.4	26.2	58.5	84.7

PRESENT AND FUTURE POSITION OF ELECTRICITY SUPPLY IN GREAT BRITAIN.—The Council of the Institution of Electrical Engineers appointed on June 8 last a Committee to consider the suggestions made in Mr. E. T. Williams's recent paper, and in the discussion, on "The Present Position of Electricity Supply in the United Kingdom." After consultation with the Incorporated Municipal Electrical Association and other similar bodies connected with electricity supply, the Committee will embody their recommendations in a Report to the Council. The Chairman of the Committee is Mr. R. A. Chattock, and the other members are Mr. C. P. Sparks (President I.E.E.), Mr. C. H. Merz, Mr. G. W. Partridge, Mr. S. L. Pearce, Mr. T. Roles and Mr. W. B. Woodhouse.

ALUMINIUM.

ALUMINIUM is one of the most abundant of the metallic elements, constituting about 15 per cent. of the earth's crust. It is a constituent of clay, and if it were possible to derive it economically from that material, we should have an inexhaustible supply at a reasonable cost. It is possible that in the near future means of extracting the metal from this source will be discovered, but for the time being we have to rely for our supply on that obtained from the mineral bauxite. Aluminium also occurs in cryolite, a double fluoride of sodium and aluminium, and corundum contains a large percentage. The former mineral is found on the southern coast of Greenland, at an Esquimaux village named Ivigut, and is exported in considerable quantities. It is used in the manufacture of white glass—a variety of porcelain. A small quantity of cryolite is also used in the extraction of aluminium from bauxite, not as a source of the metal, but to aid in fusing the bauxite. Cryolite contains 12.89 per cent. of aluminium, and corundum 53.03 per cent. The percentage of alumina in common clay ranges from 10 to 20 per cent., and in bauxite from 38 to 80 per cent. Aluminium is not obtained from corundum, as that mineral only occurs in limited quantities and can be more usefully employed for abrasive purposes and in the manufacture of plate glass and stoneware. The more useful characteristics of aluminium are its small weight and its great strength when alloyed with some other metals, so that new applications for the metal and its alloys are constantly occurring. It is largely used in the construction of aircraft and motor-cars, and, to a certain extent, as a conductor for electric power transmission. Tubing and extruded bars, which are now also made of aluminium, have great tensile strength combined with a very compact structure. The metal is also extensively used in the manufacture of cooking utensils for both military and domestic use, and in Germany and Austria it is used for shell-fuses. Aluminium is most useful in the manufacture of preserves and in the recovery of fats, and generally in industries requiring a metal which will conduct heat, will not corrode, and is not poisonous. A few fruits and vegetables have some slight chemical action on aluminium, but the quantity dissolved is so very minute as to be harmless. Aluminium is also used in the manufacture of aluminium-bronze powders, which are extensively employed in paints and in various printing processes. Aluminium foil has partly displaced tin-foil for wrapping confectionery, &c., and also in paper decorations. It has been found advantageous in the textile industry, as combined with silk it makes a brilliant fabric, which can be given any desired colour. Both Great Britain and France placed an embargo on the export of aluminium early in the war.

Not much more than two decades ago aluminium in the metallic state was only a laboratory curiosity, costing about a shilling an ounce. Now it is one of the ordinary metals of commerce employed for multitudinous purposes, some of which are mentioned above, and produced at a fraction of its former price. This remarkable change has resulted from the application of the electrolytic process to the production of the metal in large quantities. During recent years the world's production of aluminium has been as follows:—

	Tons.
1908	17,000
1909	24,200
1910	33,500
1913	62,600
1914	68,200

The plant necessary to produce aluminium on a large scale usually comprises about 400 electric furnaces, each 4 ft. to 5 ft. wide, 6 ft. to 13 ft. long, and about 2 ft. deep. The external shells of the furnaces are of steel, lined with refractory bricks, and the hearth thus formed has an additional lining of carbon blocks, which are connected to the negative pole of the electric generator and thus become the cathode. The anodes, which are also of carbon, are suspended over the interior of each furnace and hang free from the sides and bottom. Both anodes and lining blocks are sometimes made from petroleum coke, which is a by-product in oil-refining. This coke, after being crushed and heated in a kiln fired by producer gas to free it from any oil which it may contain, is finely ground and mixed with tar. This mixture is pressed by powerful hydraulic presses into the shapes required for lining blocks and anodes. They are then baked at a high temperature, which leaves them as solid blocks of carbon. Each furnace requires 20,000 amperes at 7 volts, and they are therefore placed as near as possible to the source of the current in order to avoid transmission losses. The reduction operation is that of electrolysing alumina dissolved in melted cryolite, the liberated aluminium collecting on the bottom of the furnace, whence it is tapped from time to time. The first operation in the production of aluminium is that of extracting the pure alumina from the commercial ore (bauxite), which contains many impurities that cannot be eliminated by electrolysis. In the Bayer process the ore is dissolved in concentrated soda solution, which is clarified by filtration and then diluted. The alumina is precipitated and filtered out by means of suction filters and then dried; the solution, after being recausticised by the addition of lime, is used over again. As an alternative there is the Hall process, which involves a preliminary treatment with carbon in the electric furnace and reduces the iron, silica and other impurities of the bauxite to a ferro alloy, leaving the alumina free. Other processes are the Pechinney, the Peniakoff, the Verge, the Serpek, and others.

The reaction in the process of electrolysis is as follows: $Al_2O_3 + 3C = 2Al + 3CO$. In practice, the electrolytic decomposition is not confined to the dissolved alumina, the cryolite being also electrolysed to some extent, so that there is a solution of fluorine gas at the anode, and a deposition of sodium on the cathode. This should be avoided on account of the high price of the cryolite, and also because sodium is detrimental to aluminium. This decomposition takes place when the bath becomes impoverished in aluminium, and it therefore follows that alumina should be added as rapidly as it is decomposed. In order to obtain a satisfactory condition of operation, it is necessary to add other materials to the bath, such as fluorides of aluminium and calcium and chloride of sodium, which have the effect of lowering the temperature of fusion. A mixture of cryolite with 8 to 20 per cent. of aluminina melts at 1000 deg., and the fusion point rises rapidly as the quantity of alumina is increased. Addition of fluoride of aluminium lowers the temperature of fusion to 800 deg. or 850 deg., and allows the alumina to be increased to 30 per cent. Sodium chloride added to this new mixture lowers the fusion temperature to 700 deg., and though the sodium chloride volatilises rapidly, the momentary diminution of temperature is advantageous in starting the furnace working. With the addition of the fluxes the furnace can be operated at a temperature varying between 800 deg. and 900 deg., which is most economical in the matter of current consumption. Under such conditions the electromotive force at the furnace terminals is from 7 to 8 volts, and the current from 650 to 750 amperes per square foot of anode.

The United States is now the largest aluminium-producing country in the world, the annual output having increased from 283 lb. in 1885 to over 35,000 tons in 1914. The figures given in the following table show the remarkable development in the annual production during the last two decades:—

	lb.
1885	283
1890	61,200
1895	920,000
1900	7,150,000
1905	11,347,000
1910	47,734,000
1912	65,607,000
1913	72,370,000
1914	79,129,000

Secondary supplies of metal are recovered from scrap' sweepings, trimmings, drosses, &c., as distinguished from primary supplies, which are obtained directly from ores. These secondary supplies are not of inferior quality, though from both sources the supply varies in quality and adaptability for different purposes. For the last few years the secondary supplies have been as follow:—

	lb.
1908	11,200,000
1909	24,640,000
1910	24,640,000
1913	10,325,000
1914	10,129,000

There are large aluminium factories at Niagara Falls, at Massena, N.Y., St. Louis, Illinois, and also in North Carolina and Tennessee. An American company also owns works at Shawinigan Falls, Quebec, the output of which has been commandeered by the Government. The Canadian output during 1914 was about 13,500,000 lb.

France takes first place among European countries as a producer of aluminium, owing to the extensive deposits of bauxite, containing 60 to 80 per cent. of alumina, which exist along the borders of the Mediterranean. The output in 1914 was 18,000 tons, and was produced by five large concerns with works in the Departments of Gard, Savoie, Bouches du Rhône, and Ariège. In Italy there are works at Legnano, Popoli, and Bussi, but the industry is not progressing and the output amounts to only a few hundred tons annually. The production in 1908, 1909, and 1910 was 500, 800, and 900 tons respectively, while in 1913 it had fallen to 874 tons. In Switzerland a small plant for the reduction of aluminium was established at Neuhausen as far back as 1889, and there is now another plant at Chippis; the former commenced working with an annual production of 40 tons. The same company within recent years has erected a branch in the Canton Valais, and another at Rheinfelden, as well as branches at Lend Gastien, in Austria, and at Lissa, in Silesia. In normal times Germany is a large consumer of aluminium, some of which has to be imported. During the war there appears to have been great difficulty in obtaining supplies, especially as export of the metal from Switzerland was prohibited. Consequently the price has risen rapidly, reaching a figure nearly three times as great as its price in Great Britain. The combined output of Germany, Austria, and Switzerland in 1914 was 12,000 tons. There are mineral deposits in Hesse and Nassau containing 50 to 52 per cent. of alumina, and in the Carinthia, in Austria, there are deposits with 55 per cent. of alumina. In Great Britain and Ireland the production of aluminium amounted to 16,800,000 lb. in 1914, as compared with 4,480,000 lb. in 1909 and 6,048,000 lb. in 1910. The two important companies engaged in the industry are the British Aluminium Company and the Aluminium Corporation. There are plants at Foyers and Loch Leven, in Scotland, rolling-mills near Stoke-on-Trent, and another in Wales. In Ireland there is a plant at Larne, in County Antrim, where deposits containing 45 to 54 per cent. of alumina are worked. The production of aluminium is becoming an important industry in Norway; there are plants at Stangfjord, Vigeland, Vennesta, Arendal, Christiansand, and elsewhere. The process adopted is similar to that employed in the United States. There is ample water power available, so that a large increase of the output of aluminium may be expected in the near future. The bauxite may be imported from the South of France, where it can first undergo a preliminary purification process. Both in British Guiana and in the adjoining areas in Venezuela there are very extensive deposits of a clay-like material resulting from the weathering of Archæan granites and gneisses, containing aluminium silicates and oxides. There is, however, a difficulty in separating the alumina from the silicates.

Should it in due course be found possible to utilise these deposits, there is the most ample water power available along some of the rivers of British Guiana. It is to be hoped that British enterprise will utilise this water power before United States manufacturers, who are on the look out for water power in all directions, monopolise it.

COAL SUPPLIES.—A deputation of representatives of gas and electricity undertakings waited on Mr. Marwood, of the Board of Trade, on June 29, and laid before him the various difficulties which were being encountered by the above industries at the present moment, more especially those with regard to the making of new contracts for coal for the next 12 months, both as regards quantities and prices. Mr. Marwood informed them that the Board of Trade were prepared, if approached by gas, electricity or water undertakings to use their influence through the medium of the district coal committees which had been established in the various colliery areas to procure the necessary quantities of coal required by the above-named undertakings. With regard to prices, it was further stated that if any undertaking which had cause to complain of the prices proposed to be charged for new contracts would bring such cases before the Board of Trade, the Board would be prepared to take steps, if thought necessary, so that the prices charged should be justified by the provisions of the Price of Coal (Limitation) Act.

THE CITY AND GUILDS OF LONDON INSTITUTE.—The report, just issued, of the work of the City and Guilds of London Institute during the past year shows that work, both at the Central Technical College and at Finsbury, has been greatly affected by the war. A large proportion of the older students have volunteered for active service. The authorities have, however, arranged that when these volunteers wish to return their position will receive favourable consideration. At both colleges the staff has undertaken much research work on behalf of the State, especially in connection with the submarine and aeronautical services. Unfortunately this work has been hampered by the effects of the builders' strike which delayed the completion of the Goldsmiths' Company's extension to the engineering college, and has made the equipment of the new buildings almost impracticable under existing conditions, when all manufacturing engineers are fully employed on munitions of one kind or another. The roll of honour for the City Guilds Engineering College numbers 811, of which 514 hold commissions and the remainder are non-commissioned officers or privates. The depletion of the classes is perhaps best illustrated by the fact that but 33 matriculated students obtained the diploma of the college in July, 1915, as compared with 87 in the previous year. In the case of the Finsbury Technical College, out of 59 second and third-year students, 40 suspended their studies in order to join the Forces. At the end of the session, indeed, only 14 were left, of whom 11 were studying chemistry, a branch in which more trained men are badly wanted. The report states that Professor G. T. Morgan has been appointed to succeed the late Professor Meldola. In the laboratories much work has been done in testing materials for aircraft and in making the finer kinds of gauges. The evening classes have been suspended *pro tem.*, as the entry was very small and the due obscuring of the lights which would have been necessary would have been costly. A course of experimental lectures on field telephony was given to men selected from the 2nd London Brigade of Royal Field Artillery, which proved of great service.

OIL-ENGINED QUADRUPLE-SCREW BARGE ON THE MISSISSIPPI RIVER, U.S.A.

CONSTRUCTED BY THE INLAND TRANSPORTATION COMPANY OF NEW YORK AND ST. LOUIS.

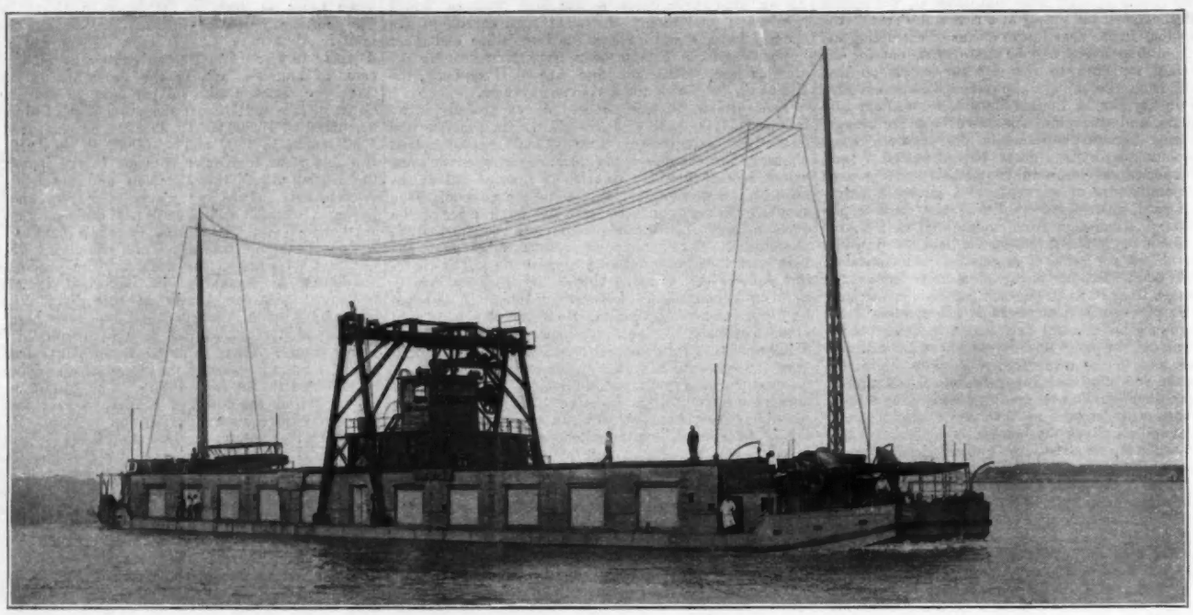
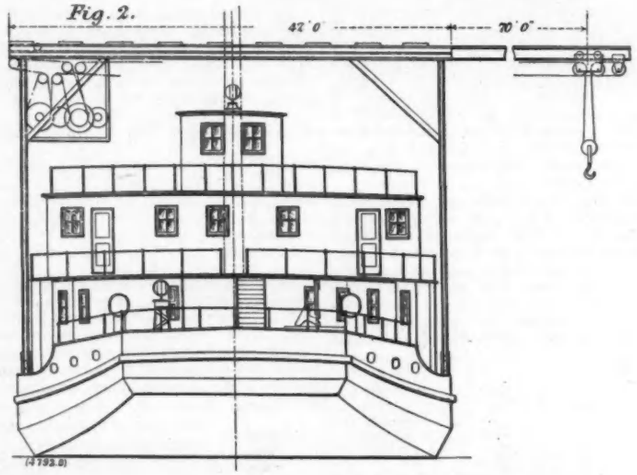


FIG. 1.

THE barge which we illustrate on this and the opposite page is interesting, not only for the features embodied in her design, but for the fact that she has been constructed as the first of a fleet to revive the long-time glory of the Mississippi as a line of communication for the transport of produce from the interior to the southern ports of America. She has been built by and for the Inland Transportation Company of New York and St. Louis, of which Mr. John H. Bernhard, Assoc. Member of the American Society of Civil Engineers, is the President, and Lord Rhondda, of Cardiff, the principal shareholder. Mr. Bernhard, a native of the Netherlands, having experience of the great utility of barge traffic in Holland, made a careful study of the means of transport adopted on the inland waterways of America, and realised that the type of vessel used was largely a cause of the gradual supersession of railway for barge traffic. He came to the conclusion that stern wheel steamers, because of the difficulties of navigating relatively narrow bends in some of the inland waters, militated greatly against the over-all speed, and he evolved a type of ship using four screw propellers to overcome such disadvantages. Moreover, the method adopted for shipping and discharging cargo at the ports lacking wharfage were, in his view, deficient. The vessel which we illustrate—the first of what it is hoped will be a large fleet—embodies the lessons derived from experiment and experience.

This barge, it will be seen from the plan, Fig. 4, has an over-all length of 240 ft. and a beam of 43 ft. When carrying 500 tons the draught is 3½ ft., and when taking the maximum cargo of 1,600 tons it is 7½ ft. The construction of the barge as shown in Figs. 2 to 4 is interesting. What might be termed a double bottom extends to above the load water line. It is built up of a series of fore and aft trusses of girder construction and a main centre line truss, supporting the flat bottom and the cargo deck. The trusses also support four transverse bulkheads dividing this double bottom or main structure of the ship into five water-tight compartments. For 184 ft. of the length of the ship there is on this main deck a deck-house or cargo hold, leaving a space of 27 ft. forward for the accommodation of windlass and other gear, and aft a space of 29 ft., in which are placed the propelling engines under the deck, and engineers' and other accommodation on the main deck. The upper deck or roof of the deck-house or cargo space, which is 10 ft. high above the main deck, is not utilised for cargo, but is steel plated and deck planked. On each side of this cargo space there are 10 openings, 8 ft. wide and 9 ft. high, through which it is possible to take wagons or trolleys carrying cargo to be housed between the main and upper decks. These spaces are closed by rolling steel doors and greatly facilitate the loading and discharging of cargo. But there are hatchways for lowering or raising the cargo in the usual way on board ship.

Fig. 2.



In the Mississippi boat of former years the method of loading and discharging at the ports, few of which have wharves, was to sling out a gangway plank from the end of the ship to the river bank, but in the barge illustrated there is a travelling gantry crane as shown in Figs. 2 and 3, having a span equal almost to the beam of the ship, and travelling on rails laid on each side of the main deck for practically the full length of the cargo deck-house. A telescope boom is fitted on this crane, so that the trolley of the crane, as shown in Figs. 2 and 4, may travel 70 ft. beyond the side of the vessel. The gantry crane has a lifting capacity of 3 tons and is electrically operated; the generating plant, to which reference will be made later, being located in the propelling engine room. Thus the crane commands all hatches, delivering to, or lifting from, the river bank at the harbours. The crane can also be used for lifting the two lifeboats carried on board. For handling cargo from boats alongside, an electric truck is carried on board, while other trucks are available at the landings. In addition there are electric endless belt conveyors for loading and discharging. It will thus be seen that the new craft is far in advance of the old type of barge used on the Mississippi. The loading facilities are superior, and the carrying of the cargo in a deck-house instead of in the hold not only facilitates loading and discharging, but reduces the possibility of cargo being affected by leakage into a hold under the water line. It will be seen from the plan, Fig. 4, that, not only for the service of the vessel, but for the carriage of cargo, there is a refrigerating store forward, and an ice box. The cold chamber has a capacity of 6,000 cub. ft., in which the temperature can be maintained at 30 deg. Fahr., when outside it is as high as 95 deg. Thus butter, eggs, and other similar produce can be carried, as well as supplies for the cook's galleys.

The *personnel* of the barge includes a captain, mate, two engineers, two oilers, four deck hands, a cook-helper and two wireless operators, who also act as freight clerks, a total of 14, suitable for a double watch. The accommodation for these is partly under the navigating bridge amidships, partly forward and partly aft, as shown on Fig. 4. A wireless system enables the vessel to keep in telegraphic contact with the offices at the terminals at St. Louis and New Orleans, as well as with the harbours *en route*, so that arrangements may be made in advance for rapidly dealing with cargo on the arrival of the barge. The two masts carrying the antennæ are partly lattice work and partly telescopic, so as to enable the barge to pass under bridges.

The propelling machinery consists of four 80-brake-horse-power engines, each with three cylinders, consuming petroleum of 29 deg. gravity, working on the four-stroke cycle, and built by Messrs. Fairbanks, Moss and Co., Limited. Each engine drives a four-bladed built-up propeller of 51 in. in diameter, the propeller shaft being set at a considerable declination

OIL-ENGINED QUADRUPLE-SCREW BARGE ON THE MISSISSIPPI RIVER, U.S.A.

CONSTRUCTED BY THE INLAND TRANSPORTATION COMPANY OF NEW YORK AND ST. LOUIS.

Fig. 3.

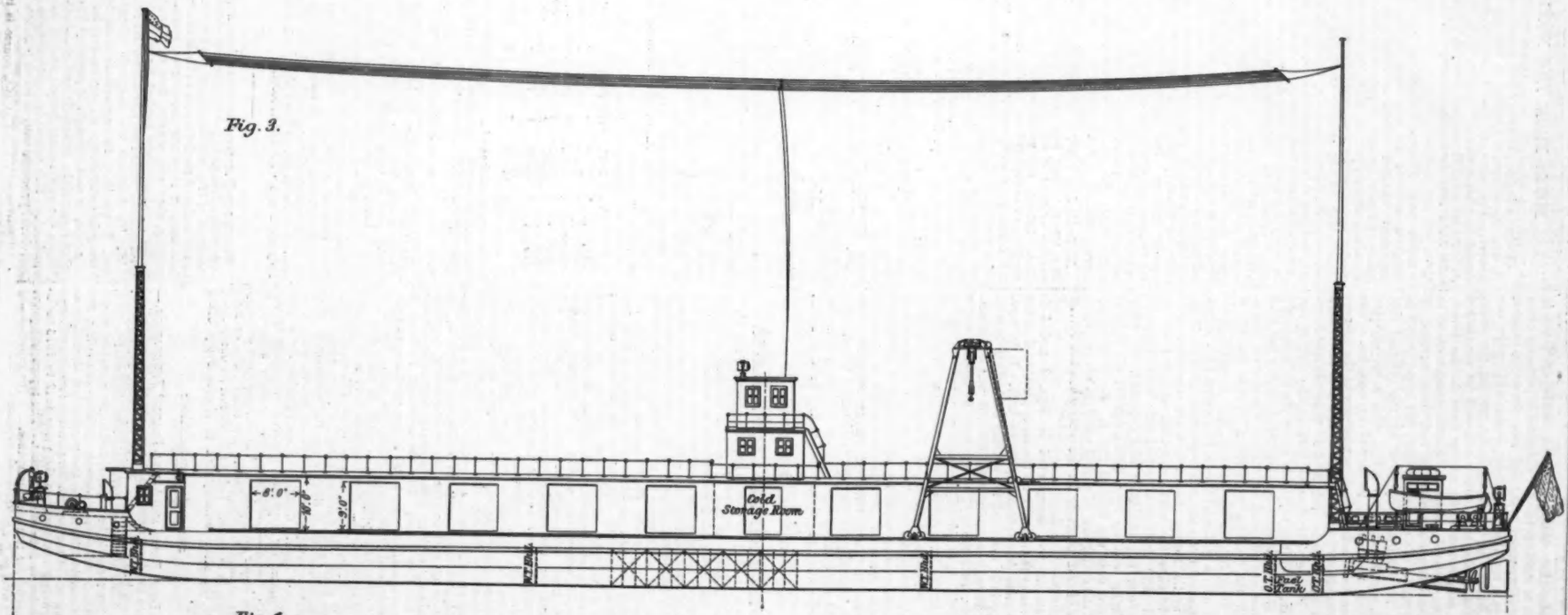
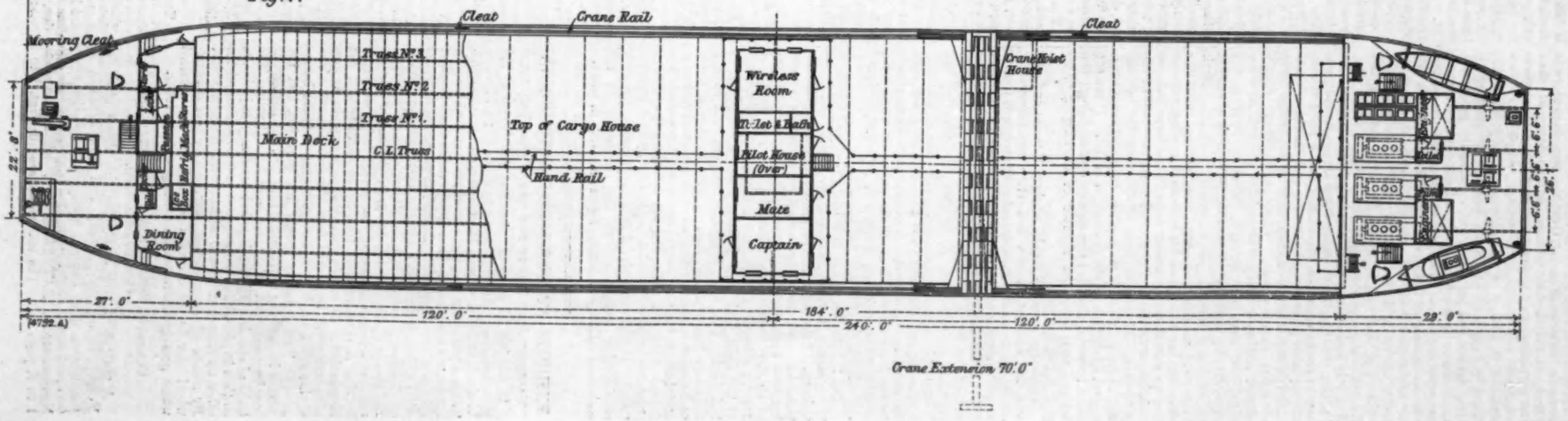


Fig. 4.



towards the stern (Fig. 3). Over the propellers there is fitted, in the sloping bottom, a trap-door, so that the propellers may be inspected and any broken blade removed and replaced, a change which has been effected in service in 9½ minutes. Compressors are fitted to supply air at 150 lb. pressure for starting up the engines and for other duty. Electric generators are fitted to be run by chain gear from one of the main propeller engines, in order to supply electricity for the various motors on board the ship. The oil engines can be unclutched from the propeller shafts at any time when the vessel is in harbour, and when a greater volume of electricity is needed for cargo handling and for harbour duties than when the barge is under way. Not only is electricity used for the gantry crane and for lighting the ship, but there are fitted three search-lights, one at the bow, one on the bridge, and a third astern, all operated from the pilot-house, and having a combined power of 18,000 candles, that on the bridge being of 9,000 candle-power. Electrically-driven rotary pumps are used for jet propulsion through an 8-in. nozzle on each side forward, so as to increase the manœuvring capacity of the ship in coming alongside or leaving a wharf. The manœuvring of the vessel, however, is generally very satisfactory, notwithstanding her light draught, because the wing engines can be run ahead or astern at will, and large balance rudders, as shown in Fig. 3, are fitted abaft each of the propellers. Electric current is also used for heating and cooking; there is no coal fire on board the vessel, a great advantage in the prevention of fire. There are three powerful electric bilge pumps operated from the bridge, and these are capable of discharging 8,000 gallons per minute.

The barge carries 2,000-lb. anchors forward and aft, and the winches at bow and stern are electrically driven by 4 horse-power motors. The vessel, too, is fitted forward, as shown in Fig. 4, with a gun for firing, towards the shore or to another ship in distress, a life-saving line for a distance of 1,750 ft. In the swift currents and shallows, it is often necessary on the Mississippi to get a line ashore in order to haul the boat over the shallows, and the life-saving line may be useful in this respect. One of the life-boats, placed forward on davits, is a 20-ft. power-driven launch, capable of maintaining a speed of 15 miles per hour; the other is an ordinary row boat.

The "Inco No. 1" is now in service maintaining a three-weekly service between St. Louis and New Orleans. Two other vessels are in course of construction, in order that there may be a weekly service between these terminal cities. These new vessels are of similar construction, but will have a length of 310 ft., a beam of 56 ft., and a depth from the bottom of the main deck of 9 ft., the draught being 7 ft. at full load. The four propelling engines will have a collective power of 600 horse-power, to give a speed of 20 miles in slack water, which is rather more than is maintained by the barge which we illustrate. The future of the new enterprise will be regarded with considerable interest, in view especially of the Panama Canal. It will certainly, if it is developed to any very considerable extent, relieve the congestion on the mainland railways in times of great activity in trade.

EXHIBITS AT THE MANCHESTER SHOW.

Haulage Attachment for the Wyles Plough.

In our last issue we gave a short description of the plough shown at the Royal Show by Wyles Motor Ploughs, Limited, of 5, Carr-street, Manchester, and we now illustrate on page 14 a reaping attachment with which this implement has recently been fitted. As its name implies, the machine was originally planned for ploughing purposes only, although provision was also made for the driving of stationary machinery by means of a belt pulley. By the new attachment, however, the motor can be used for haulage purposes, the plough being removed, leaving a three-wheeled tractor, as indicated in our illustration. As will be seen, the implement in its new adaptation can be steered from the driver's seat. The engine has a single cylinder developing 11 brake horse-power. Two running speeds are provided, and the weight in working order being very low, the implement can be used with advantage even on soft soils. The level of the driving wheels is independently adjustable, so that in ploughing one may run in the furrow and the other on unbroken ground without tilting the machine. By means of dog-clutches, moreover, either driving-wheel can be disconnected at will, an arrangement which greatly facilitates the making of sharp turns.

Portable Shears for Sheet Steel and Corrugated Iron.

A couple of very handy portable shears made by Messrs. Montgomery, Smith and Co., Limited, of Keynsham, near Bristol, were shown at the stand occupied at the Royal Show by Fastnut, Limited, 115, Newgate-street, E.C. These are illustrated in Figs. 1 to 5, page 14. The tool represented in Figs. 1 to 3 is intended for cutting flat iron sheets up ¼ in. in diameter or steel up to $\frac{1}{16}$. It gives a perfectly clean cut. As represented in the full lines, the tool is suitable for use as a portable implement, being held by the one handle whilst the cut is made by moving the other. By means of the attachment indicated by the dotted lines it can, however, be readily fixed to the bench, this being advisable where the heavier gauges are to be cut. The cutters are discs of tool steel, serrated or knurled round the shearing edges; the upper cutter is coupled to the operating lever by the internal face ratchets shown, and is rotated with a step-by-step motion as the handle is moved to and fro. The serrations provided on the circumference of the cutters, already explained, grip the sheet and feed it forward between the cutters; the feed is thus entirely automatic. The vertical distance between the cutters can be regulated by the adjusting screw shown separately in Fig. 2. In the position indicated by the full lines the cutters are adjusted for cutting the thicker sheets, whilst in the position represented by the one set of dotted lines the cutter centres are brought closer together into a position suitable for cutting thin sheets. When moved over the other position marked "Release" in the figure, the cutters are separated sufficiently to clear the work, and thus allow it to be removed after making a partial cut, when required. A transverse adjustment is also provided, the lower cutter being held up by a spring against the bearing nut shown near the base of Fig. 1. By screwing up this nut the cutter can be moved axially, thus providing a means of compensating for the wear when the cutters are re-ground.

The second tool represented in Figs. 4 and 5 is constructed substantially on the same plan, so that the same general description applies to both. It is, however, specially intended for cutting corrugated iron in place. Though weighing only 5 lb., it will cut sheets up to No. 18 S.W.G. The cut may be made along a straight line in any direction, parallel, perpendicular or oblique to the corrugations, or a curve can be followed at will. As in the case of the tool already described, the feed is automatic. With this tool it is claimed that there is no necessity for the cutting of corrugated iron before erection. It can be erected as received, and when in place trimmed off as required. The pressure necessary for the feed is obtained by screwing down the adjustment screw shown, whilst by screwing it back the work can be released at any point of a cut.

NOTES FROM THE UNITED STATES.

Philadelphia, June 21.

After a week or two of relative inaction the steel market has taken on fresh activity to some extent; it is impossible to report the extraordinary activity of a few weeks ago, because mills are sold up for months ahead. European demand, especially for munition and munition material, will continue to be a very important factor for an indefinite period. The Russian Government has established a credit of 50,000,000 dols., and this was immediately followed by orders for 200,000 tons of barbed wire, with negotiations pending for 10,000 freight cars and something in excess of 600 locomotives, some statements saying 1,000, besides 350,000 tons of steel rails, the greater part of which will be rolled by the Steel Corporation. The Russian Government is very anxious for the quickest possible delivery; it is understood that France is endeavouring to establish a credit of 100,000,000 dols., to purchase war supplies. The railroads are increasing their orders for structural material, but the aggregate of orders at this time is somewhat less than a year ago. New shipbuilding companies, which are hastening the completion of facilities for the early building of ships, are anxiously seeking acceptance by the mills of contracts for steel plate. The Pennsylvania Railroad is seeking material to build 5,000 70-ton gondolas, and the Chesapeake and Ohio wants 1,500 box cars. The New Haven Company is preparing to equip its road with 100 electrical locomotives. Blast furnaces have been running at top speed for a year or more and some of them, probably many of them, will have to blow out for re-lining, thus reducing output at a time when full production is of very much consequence. Prices, of course, remain at the topmost limit. Conditions are ripening for a very heavy demand for structural material, especially by the railroads, and the demand from outside sources is assuming larger proportions. The expansion of capacity is being pushed to the limit. No relief from existing conditions is in sight. Labour is difficult to obtain, not only in the steel industry but in almost every other industry.

The Iron, Steel and Allied Trades' Federation.—We have received from the Supervisor of the Statistical Bureau of this Federation, Mr. G. C. Lloyd, 28, Victoria-street, S.W., a copy of the Statistical Report for 1915, which has recently been presented to the members of the Federation. The report covers statistics of the iron and steel industries, including the production of coal, coke and iron ore of the British Empire and foreign countries. The figures given apply to the years 1912 to 1915 inclusive, as far as data are available. The report will prove most useful for reference purposes.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Still there is no intimation of any immediate re-opening of the pig-iron warrant market. The stock of No. 3 iron in store continues similar to what it was a week ago, for in the week ended on Saturday only 778 tons had been exported, as compared with 2,052 tons during the corresponding week a year ago.

Scotch Steel Trade.—Perhaps at the moment the unsettled state of the coal trade is one of the most important features connected with the steel trade locally, for any increase in price will undoubtedly have a marked effect upon all manufactured steel and iron, causing an entire revision of the present rates. As it is, those which are not already controlled by Government order evince a certain hardening tendency, and it is feared that ere long this condition will extend to other numbers as well, and that a higher maximum level will be reached. In every direction the activity remains unabated, for, either directly or indirectly, the local works are all employed in turning out material for Government contracts, the demand for shell bars especially being so great that manufacturers are experiencing no little difficulty in connection with the delivery. In fact, the continued pressure for all classes of war material is more and more affecting ordinary mercantile business, curtailing it in every direction, the export trade being an especial sufferer. For home delivery ship-plates are 11*l.* 10*s.* per ton, with boiler-plates 20*s.* per ton in advance of this figure, and angles 11*l.* 2*s.* 6*d.*; while the prices for export ship-plates may be 14*l.* 15*s.* or even 15*l.*, boiler plates 15*l.* 10*s.* and upwards, and angles 14*l.* or thereabouts, all f.o.b. Glasgow.

Malleable-Iron Trade.—The conditions of the malleable-iron trade remain practically unaltered, the greatest possible amount of business being put through all the time. Indeed, the requirements of the home market continue so extensive that makers have no opportunity for considering any export demands whatever, this being especially so with their steel products. Deliveries are constantly running behind. "Crown" bars for export remain firm at 14*l.* 2*s.* 6*d.* per ton, and for the home market the price is still 14*l.* 12*s.* 6*d.* less 5 per cent. "Unfavourable" specifications may even top these figures.

Scotch Shipbuilding in June.—Even as compared with May, the Clyde shipbuilding during the past month shows a substantial decrease, only three vessels with a gross tonnage of 11,580 tons having been launched in June. For the half-year just ended there have been launched on the Clyde 16 vessels, of 58,063 tons, a decided falling-off from the 50 vessels, of 138,973 tons, during the first six months of last year, and the 129 vessels, of 267,677 tons, in the corresponding period of 1914. Despite the rumours current some weeks ago, there has been little evidence of the expected speeding up in the production of merchant shipping which Government was supposed to be arranging, nor has there been any intimation of new contracts for this class of work, although quite a number of merchant vessels are well on the way, particularly on the lower reaches of the river, where the bulk of this work is undertaken. One launch took place in June on the Forth—the Redstone, built and engined by Messrs. Jeffrey and Co., Alloa, for Glasgow owners. The following table shows the merchant output for the half-year:—

	Clyde.		Forth.		Tay.		Dee.	
	Vess.	Tons.	Vess.	Tons.	Vess.	Tons.	Vess.	Tons.
Jan. ..	1	70	—	—	—	—	—	—
Feb. ..	2	5,640	—	—	—	—	6	1027
March ..	2	11,246	3	2563	—	—	4	815
April ..	2	7,557	1	214	1	7400	—	—
May ..	6	21,970	2	2224	—	—	2	420
June ..	3	11,590	1	200	—	—	—	—
	16	58,073	7	5201	1	7400	12	2262

In the upper reaches of the Clyde work is almost entirely concentrated upon Government contracts, of which, naturally, no details are available.

Glover's Almanac.—We have received from Messrs. W. T. Glover and Co., Limited, Trafford Park, Manchester, one of their almanacs for the 12 months from July 1, 1916, to June 30, 1917, the fifteenth year of issue. Its features are well known, and need no special comment; it gives, besides the usual familiar type of sketches, a very large number of abstracts from technical journals and from papers read before technical societies, dealing with all applications of electricity. As in former years, the authors have set out to join *l'utile à l'agréable*, and in this they have met with full success.

Books for British Prisoners Abroad.—Regimental Care Committees, and relatives and friends of British Prisoners of War will do them a good service by bringing to the notice of the interned, in their letters to them, the fact that, if they are desirous of carrying on serious reading, they can obtain, free of charge, educational books on almost any subject by writing to Mr. A. T. Davies at the Board of Education, Whitehall, London, S.W. To facilitate the despatch of parcels of books and, if possible, the organisation of an educational library in every camp, all applications for books should, as a rule, be sent through, or endorsed by, the senior, or other responsible, British Officer or N.C.O. in the camp. Where for any reason (which should be stated in the application) this course is impracticable, requests from individual prisoners will, as far as possible, be acceded to.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Collieries are kept on the full stretch to furnish all the demands made upon them, but the position is rendered the more difficult by considerable slackness on the part of the miners. It is felt that this trouble will not be overcome until these men have been graded as munition workers. A district committee has just been appointed in this area, consisting of representatives of the masters and the men, to deal with the habitual slackers. The committee is empowered, in addition to fining the men, to order the withdrawal of their badges. This drastic regulation may have a salutary effect upon bad timekeepers. The committee set up by the Ministry of Munitions to direct the supplies from local collieries has now got into thorough working order, and has allocated to the respective concerns the amount of fuel to be supplied each week for works, railways, or for shipments to Allied Powers. This has rather disturbed the ordinary trade channels, and the private customers find it exceedingly difficult to get supplies on a large scale. The local demand for steam fuels remains very great, and is growing rapidly. Full tonnage of the large coal is available for the works, but not in such quantities as to enable them to build up their stocks for the winter season. The shipments to France, Italy and Russia are maintained at a regular figure, but those to neutrals show a considerable falling-off, due to a tightening of the licensing restrictions. Contract accounts absorb nearly all the gas coal output. Slacks are freely bought. Coke is being extensively used. Quotations:—Best branch handpicked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire best brights, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire house, 16*s.* to 17*s.*; best large nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; small nuts, 15*s.* to 16*s.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 8*s.* to 9*s.*

Iron and Steel.—The unsettled position with regard to the prices of materials has not been without considerable influence on the general position. Buying has only been on a comparatively small scale, and even this limited amount of business is subject to any subsequent regulations of the Prices Tariff Committee. Millers have persistently pressed their claims upon the Committee, and there has been much speculation as to the outcome. The decisions of the Committee are awaited with interest in the Sheffield and district trade circles. The scarcity of iron still prevails. Makers of hematites are giving increased attention to the production of special qualities for munition purposes, with the consequence that the output of mixed brands has been reduced. The consumption of the common irons is very heavy in the large engineering works, but the needs of the makers of light castings are not so great as usual, owing to the falling-off in the volume of business. Munitions continue to have the first call on all semi-manufactured steel, and the private trade suffers through the insufficient quantities available. It is asserted by buyers that the maximum prices for basic billets are not adhered to, and orders are not accepted at anything like the official markings. American steel shipments do not relieve the situation, for, though freights are less costly, steel values have risen enormously on the other side of the Atlantic, and buying cannot be done profitably here. All the important steel works report that they are working under tremendous pressure, and their full capacity is tested to the uttermost. Enlargements and extensions are in progress at many of the more famous works, and others are acquiring modern plant. A Rotherham company have erected a new factory to produce electrodes which are used in connection with the electric furnaces that are being laid down so extensively in the city. Steps have been taken which will lead to a marked speeding up in the production of heavy and light forgings, hack-saws, twist-drills, alloys and cutlery. Contrary to the general expectation, there has been no perceptible improvement in the shipments of wolfram ore, and steel-makers find that their output is affected by the shortness of the deliveries of tungsten. It is officially intimated, however, to the manufacturers that the movement to accelerate the output from the Burma and Australian ore-fields has now made appreciable progress, and the full effect of this wise undertaking will be felt in good time. The Argentina ore supplies, which are largely German owned, are being purchased by the American steel-makers. The quantities are only small, and the prices correspondingly high. Large quantities of drills of the high-speed variety are daily turned out in Sheffield, but there is also a great demand for the cheaper carbon types, and all orders are not being met, even with the aid of the American importations. A local firm is aiming at capturing a German European trade by equipping a specially erected factory to manufacture small tools, such as pliers, spanners, nippers, tinsmith's snips, garden shears, machine-made scissors, razors, and surgical instruments. The boom in the sale of scythes, sickles, spades, forks, and farm and garden implements has been one of the best on record. Owing to their depleted staffs manufacturers have had a harassing time to meet all demands, but they have done their work well, for there does not appear to have been any pronounced shortage. Rustless steel cutlery continues to win popularity, and the demand is proving very great. Expansion is reported in the foreign and colonial trade, and the week's mail has brought orders for saws, files, knives, springs, steel wire, and steel.

ELECTRICAL SMELTING WORKS AT STAVANGER.—We read in the *Anglo-Norwegian Trade Journal* that a new company has been formed at Stavanger with a capital of 1,000,000 kr., for the purpose of establishing electrical smelting works near Lysefjordin.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—It is expected that one or two additional blastfurnaces will be put into operation this month, but the full number it was intended to have running in July may not be active until August, owing to reasons for unavoidable delay. In the meantime the local Committee responsible for distribution of pig-iron are allotting supplies in a manner which leaves local consumers little room for complaint. Though it is still impossible to secure licences for shipment to neutral countries, there are grounds for belief that some iron will be released shortly for export, under certain conditions, to customers in Scandinavia. For home consumption No. 3 Cleveland pig is firm at 87*s.* 6*d.*, and that figure is also named for No. 4 foundry and No. 4 forge; while No. 1 commands about 4*s.* higher. The export price of No. 3 runs from 95*s.* to 97*s.* 6*d.*, and foundry 4 can be bought at a little less. No. 1 for export is in the neighbourhood of 100*s.*

Stocks of Pig-Iron.—Stocks of pig-iron alter little. Makers may be said to have none. The quantity of Cleveland pig in the public warrant stores here stands at 29,632 tons, composed of 28,371 tons of No. 3 and 1,261 tons of other kinds of iron deliverable as standard. So far this month the stock has been increased by 162 tons, 446 tons of No. 3 having been added and 284 tons of standard iron having been withdrawn. On the 1st of the month there were warrants in circulation for 13,000 tons—12,100 tons of No. 3 and 900 tons of standard iron.

Hematite Iron.—The East Coast hematite branch of the staple industry presents no new feature of moment. Very little iron is purchasable for early delivery, there being no stocks, and producers being well sold. Licences for shipment, except to France, are unobtainable. Nos. 1, 2 and 3 are nominally 140*s.* for general export. The price of mixed Nos. for home consumption, and for shipment to France, stands at 122*s.* 6*d.*

Foreign Ore.—Values of foreign ore are moving upward notwithstanding the continued very large supplies coming steadily to hand on running contracts, and the fact that consumers are now carrying considerable stocks. Imports to the Tees during the month of June reached no less than 251,481 tons, and so far this month the unloadings here amount to 45,318 tons. The rise in price is due to the very firm attitude of the mine-owners abroad, all of whom are understood to be well sold. The mine-owners in Spain declare that they have been compelled to advance quotations because of higher railway rates, and they now name 20*s.* f.o.b. Bilbao as the price of Rubio ore of 50 per cent. quality. This makes the ex-ship Tees quotation 37*s.* on the basis of a 17*s.* Bilbao-Middlesbrough freight, the figure at which controlled consumers are enabled, through the Government, to arrange the conveyance of ore. In the open market, however, steamers, Bilbao to the Tees, continue to be fixed at 19*s.*, so that any non-controlled consumer needing best Rubio would have to pay 39*s.* ex-ship Tees.

Coke.—There is a good demand for coke and quotations are stiff. Local consumption is large, and is likely to become heavier. Average blastfurnace coke is 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens is quoted for qualities low in phosphorus.

Manufactured Iron and Steel.—The finished iron and steel works are kept fully occupied almost entirely on Government work, and buyers with ordinary private orders to give out experience much difficulty in placing them. Quotations all round are very strong. Common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship-plates, 11*l.* 10*s.*; iron ship-angles, 13*l.* 15*s.*; iron ship-rivets (¾-in. diameter), 17*l.* 10*s.*; iron ship-rivets (⅝-in. diameter), 18*l.* 10*s.*; packing iron and steel (parallel), 10*l.*; packing iron and steel (tapered), 12*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship-plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship-rivets (¾-in. diameter), 18*l.* 10*s.*; steel ship-rivets (⅝-in. diameter), 19*l.* 10*s.*; steel sheets (singles), 18*l.* 10*s.*; steel sheets (doubles), 18*l.* 15*s.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; and heavy steel rails, 11*l.* 5*s.*

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough during June, though much below what could be wished, were, under the conditions that prevailed, by no means unsatisfactory. Loadings of pig-iron amounted to 52,888 tons, as compared with 67,880 tons for the previous month, and 36,806 tons for June last year. Of the pig despatched last month 50,758 tons went to foreign countries, and 2,130 tons to coastwise customers. Again France was by far the largest receiver, taking no less than 40,449 tons, while Italy imported 3,314 tons, and China and Japan, 4,205 tons. With the exception of 2,350 tons to the United States no pig-iron went to neutral countries. Shipments of manufactured iron and steel during June totalled 38,702 tons, of which 35,083 tons went abroad, and 3,619 tons coastwise. France, with an import of 27,022 tons, was the largest customer. India and Ceylon received 2,443 tons.

NOTES FROM THE SOUTH-WEST

Cardiff.—The best descriptions of steam coal have been again scarce and the requirements of the British and Allied Governments have continued heavy. Under these circumstances, although outputs have improved to some extent, the quantities of coal available for exportation have been much curtailed. Licences for exports to neutral countries have been difficult to obtain; and although shipments to France have been retarded by the limitation of freights and prices scheme, it appears probable that there will be no excess of coal for some time to come. It is understood that in the course of this month exports to Italy, Algeria and Egypt are likely to be brought under a similar limitation; a limitation of Mediterranean freights to Allied countries and British possessions is also expected to be brought into operation. The best Admiralty large steam coal has been to some extent nominal; secondary descriptions have made 49*s.* to 50*s.*; Monmouthshire Black Veins, 49*s.* to 50*s.*; ordinary Western Valleys, 49*s.* to 50*s.*; Eastern Valleys, 46*s.* to 48*s.*; best bunker smalls, 29*s.* to 30*s.*; and cargo smalls, 24*s.* to 25*s.* per ton. In bituminous coal the best households have made 23*s.* to 24*s.* at the pits; No. 3 Rhondda large, 49*s.* to 50*s.*; smalls, 32*s.* to 34*s.*; No. 2 Rhondda large, 36*s.* to 38*s.*; and No. 2 smalls, 25*s.* to 26*s.* per ton. The latest quotation for patent fuel has been 50*s.* to 51*s.* per ton. Special foundry coke for export has made 62*s.* to 65*s.*; good foundry coke, 60*s.* to 62*s.* 6*d.*; and furnace coke, 50*s.* to 55*s.* per ton.

Welsh Coal for France.—The Powell Duffryn Steam Coal Company, Limited, has organised the Normandy Shipping Company, Limited, which is to be entirely devoted to French trade. The Powell Duffryn Company has for some time carried on a French branch under the style and title of the Compagnie Française des Mines Powell Duffryn; the branch has depots at Rouen, Havre, Nantes and Bordeaux; and a new British undertaking has now been registered under the designation of the Normandy Shipping Company, Limited; two steamers, which are to be entirely used for French trade, have been launched, and it is expected that they will shortly be ready for sea. The management is in the hands of Messrs. Stephenson Clark, and Co.

Western Trade Matters.—The steamers Begonia and Annie, purchased by Messrs. Jenkins, Richards and Evans, Cardiff, have been re-named the Maindy Bridge and the Maindy Abbey; the Maindy Bridge is 3,653 tons gross and the Maindy Abbey 3,743 tons gross.—The steamer Busuta, 2,876 tons gross, has been sold to Messrs. D. P. Barnett and Company, Cardiff. The directors of the Maindy Shipping Company, Limited, submit accounts for a period of 10 months and 27 days, and recommend a dividend and bonus of 22½ per cent., leaving 2,141*l.* to be carried forward. The company is now working two steamers and has further tonnage under construction.—After a prolonged delay, an award of Judge Connor on three points of difference raised by the South Wales Miners' Federation has been accepted and applied to the parties by the Local Conciliation Board; the arrangements, which are generally favourable to the men, are to date from July 22, 1916.—The directors of North's Navigation Collieries, Limited, recommend an interim dividend at the rate of 10 per cent. per annum on both preference and ordinary shares.—The directors of the Globe Shipping Company, Limited, at a meeting at Cardiff, Lord Rhondda presiding, decided to pay an interim dividend at the rate of 15 per cent. per annum for the past half-year.—A new pit has been completed by the Newport, Abercarn Black Vein Steam Coal Company, Limited, and has now reached an output of between 700 and 800 tons per day; if the necessary labour could be obtained, the production would be at least three times that amount. The ordinary shares receive a dividend of 12½ per cent. for 1915-16.—The directors of the Imperial Navigation Coal Company recommend a dividend of 10 per cent. for the six months ending June 30. At the annual meeting of the Ebbw Vale Steel, Iron and Coal Company, Limited, the chairman (Colonel Sir C. Allen) said a total of 1,800,000 tons of coal had been raised by the company in its past financial year. The property consolidating adjoining areas and by-product coke ovens had proved an unqualified success.—The directors of the Dulcia Steamship Company recommend an interim dividend at the rate of 25 per cent. per annum.—The Board of the Celtic Collieries, Limited, recommend an interim dividend at the rate of 10 per cent. per annum, payable August 1.—Arrangements for a transfer of a majority of the shares in Powell's Tillery Steam Coal Company, Limited, to the Ebbw Vale Steel, Iron and Coal Company, Limited, and Messrs. T. Beyna and Co., have now been completed.—The dividend on the ordinary shares of the Tatem Steam Navigation Company for the six years ending with 1916 inclusive have been as follows:—1911 and 1912, 10 per cent. per annum; 1913, 1914, 1915 and 1916, at the rate of 15 per cent. per annum.—At the annual meeting of the Tredegar Iron and Coal Company, Limited, a decrease of 152,000 tons was reported in the year's coal output, the excess profits tax also imposed heavy burdens upon the company.—Efforts are in contemplation with a view to the development of shipbuilding at Chepstow; ships of about 8,000 tons deadweight will probably be built at first, but it will be possible to turn out vessels of 11,000 or 12,000 tons deadweight, as there would be a sufficient depth of water for launching.—Negotiations are stated to be pending for the transfer of the British Mannesmann Tube Company to Baldwin's, Limited.

PROPOSED NORWEGIAN-AMERICAN BANK.—The recently suggested Norwegian-American bank is beginning to take shape, says the *Anglo-Norwegian Trade Journal*, inasmuch as a representative of Norwegian interests is at present in New York investigating the possibilities of establishing such a bank there. Such an institution is considered highly desirable, having regard to the great development of commercial relations between the two countries. Half of the proposed capital is expected to be subscribed in Norway and the other half in the States.

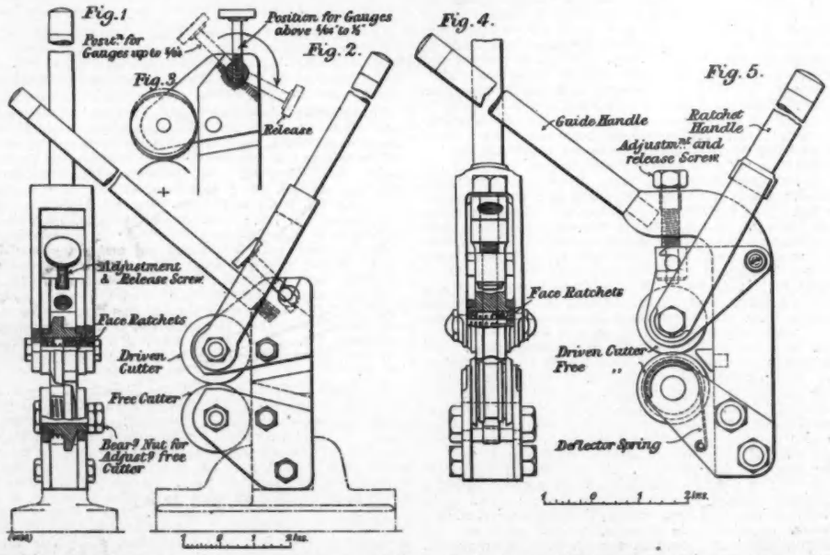
EXHIBITS AT THE ROYAL AGRICULTURAL SHOW AT MANCHESTER.

(*For Description, see Page* 12.)

MOTOR-PLOUGH AND REAPER ATTACHMENT; WYLES MOTOR PLOUGHS LIMITED, MANCHESTER.

NEW SOUTH WALES HYDRO-ELECTRIC SCHEME.—The Snowy River hydro-electric scheme is, in the view of the Minister for Public Works, more important than the Great Lake undertaking in Tasmania, which has now been partly carried out. The State proposal is estimated to cost 5,000,000*l*. The departmental figures show that electric power will be capable of being supplied in Sydney from the Snowy River at one-eighth of a penny per unit. The cheapness of this can be judged from the fact that some municipalities which supply electric power charge 4*d*. per unit for it.

THE POSITION ON THE GERMAN IRON MARKET.—A report from Saarbrucken states that, in spite of, or it may be on account of, the war, the heavy German iron industry exhibits continuously rising prices. Since the beginning of the year everything connected with the iron industry, from iron ore to the most insignificant article of hardware, has been steadily rising, and it is impossible to say whether the top has been reached. The scarcity of available material is demonstrated by the works holding out for ever longer terms of delivery, and, in contrast to previous booming periods, there does not at present appear the slightest likelihood of a retrogressive movement for some considerable time to come. Formerly a rise in prices led to an enlarged production, but this is out of the question at present on account of the shortage of labour caused by the war. Besides, in ordinary times of peace the large works used a considerable amount of iron themselves in improving and enlarging the plant. All this has—temporarily, at least—come to an end, and hardly anyone is thinking of works extension at present. Only the most necessary repairs are undertaken, every available hand being used to increase the production. Times are too good for syndicate formation or price conventions, and even the members of the various export combines do not abide by the fixed prices, inasmuch as they almost all try to obtain better prices in neutral countries than the fixed quotations. Even after peace is concluded no alteration in prices is likely to ensue for some time to come. It must also be remembered that, perhaps with the exception of section bars, there are no stocks at the works, and the large trading stocks are also almost exhausted. All these circumstances must be considered when endeavouring to form an estimate of what will be the position after the conclusion of the war. No doubt a time of slackness will some day set in, but it is likely to be a good long way off, and it will not, when it comes, be so much felt if only a certain amount of caution be exercised so as not to increase prices unduly in the immediate future.



PORTABLE SHEARS FOR CUTTING STEEL AND CORRUGATED IRON; MESSRS. MONTGOMERY, SMITH AND CO., LIMITED, KEYNSHAM, NEAR BRISTOL.

SYDNEY UNDERGROUND RAILWAYS.—A start will shortly be made with the underground tunnels of the Sydney city railway system. Two sections of the scheme, the Wynyard-square and the Quay, have been handed over to Messrs. Norton Griffiths and Co.

THE JAPANESE NAVY.—We read in the *London and China Telegraph* that a German floating dock, which the Japanese navy captured at Tsingtau, will be towed to Sasebo by the training vessel Fuji. The dock is valued at 2,000,000 yen. The Japanese navy has appropriated 100,000 yen for overhauling it. The keel of a big battleship, to be called the Nagato, will shortly be laid at Kure. The battleship will be armed with 15-in. guns, and will have a tonnage of over 30,000 tons and a speed of 24 knots. The Navy Department is now preparing to build 16 small-sized transports at a cost of 36,650 yen. These transports will be built at various naval shipyards within this year. According to the investigation by the Communications Department, steamers of over 1,000 tons which have been constructed by Japanese shipbuilders since January last number 17, the total tonnage being 66,561 tons.

FISHGUARD HARBOUR WORKS; THE CONST

MESSRS. COODE, MATTHEWS, FITZMAURICE, AND WILSON, MM. INST. C.E., LOND

(*For Descriptio*

FIG. 4. VIEW OF BREAKWATER FROM THE CLIFFS ADJACENT TO LANDWARD END, WITH POWER-STATION TO THE LEFT.

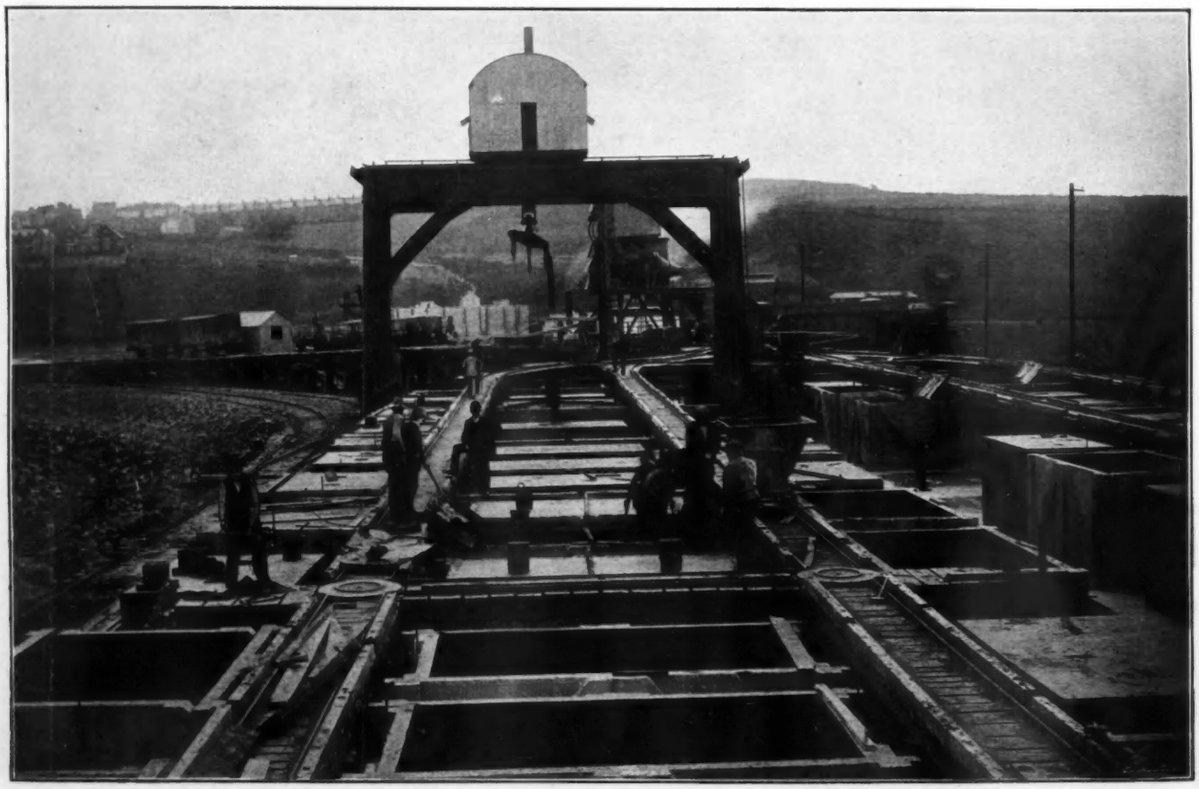


FIG. 6. THE BLOCK-MAKING YARD, WITH MOULDS READY TO RECEIVE CONCRETE, IN THE FOREGROUND.

CONSTRUCTION OF THE NORTH BREAKWATER.

C.E., LONDON, ENGINEERS; MESSRS. TOPHAM, JONES, AND RAILTON, CONTRACTORS.

(For Description, see Page 5.)

FIG. 5. VIEW OF BREAKWATER, WITH QUARRY IN THE FOREGROUND.

FIG. 7. THE TITAN CRANE DEPOSITING BLOCKS AND PELL-MELL FORMATION IN FOREGROUND.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson & Sons, Manning Chambers. Montreal: Sells, Limited, 202, Shaugnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Subscriptions and Advertisements, Librairie B. Tignol, 53bis, Quai des Grands-Augustins, Paris. Also for Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland, and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Longstreet.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 967-968, Monadnock Block.
For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£1	15	6

The increase in the annual subscription is entirely due to the new postage rates on newspapers.

For Canada—			
Thin paper copies	£1	11	6 ($7.65)
Thick ,, ...	£1	16	0 ($8.75)
For all other places abroad—			
Thin paper copies	£1	16	0
Thick ,, ...	£2	0	6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3863 and 8508 GERRARD.

CONTENTS.

	PAGE		PAGE
Steam Flow into a Compound Steam-Turbine (*Illustrated*)	1	Notes from the South-West	13
The National Physical Laboratory in 1915-16 (*Illustrated*)	3	Admiral Jellicoe's Despatch	15
Fishguard Harbour Works (*Illustrated*)	5	Poisons used in the Rubber Industry	16
Triple-Turret High-Speed Vertical Turning and Boring Mill (*Illustrated*)	7	The French State Railways	17
Industrial Notes	8	Note	18
The Working of the Boiler Explosions Acts	8	Literature	19
Aluminium	9	Books Received	21
Oil-Engined Quadruple-Screw Barge on the Mississippi River, U.S.A. (*Illustrated*)	10	Draughtsmen	21
Exhibits at the Manchester Show (*Illustrated*)	12	Oil-Engine Nomenclature, and the Diesel Engine	21
Notes from the United States	12	Diagrams of Three Months' Fluctuations in the Prices of Metals	22
Notes from the North	12	Repairing Fractured Locomotive-Engine Frames by Oxy-Acetylene Welding (*Illustrated*)	23
Notes from South Yorkshire	13	Movable Sector Weir near Bremen (*Illustrated*)	23
Notes from Cleveland and the Northern Counties	13	Colonial and Foreign Engineering Projects	23
		Continuous Current Railway Motors (*Illustrated*)	24
		ENGINEERING Patent Record (*Illustrated*)	28

With a Two-Page Plate of the FISHGUARD HARBOUR WORKS; THE CONSTRUCTION OF THE NORTH BREAKWATER.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JULY 7, 1916.

ADMIRAL JELLICOE'S DESPATCH.

THE eagerly yet confidently awaited despatch of Admiral Sir John Jellicoe, Commander-in-Chief of the Grand Fleet, regarding the action in the North Sea on May 31, has now been issued. Only very general deductions are possible, because, while the work of the squadrons and of many of the individual ships is narrated with fulness and precision, the list of ships which took part in the action has been withheld from publication for the present, in accordance with practice, so that it is not possible to arrive at any conclusion as to this supreme test of those qualities of design which have been the study of a succession of naval architects and marine engineers for many years. Nor can any safe analysis of the tactics be ventured upon. The one definite conclusion which can be drawn is that the action was, from every point of view, a great victory for the British Navy, while there is no question that the highest traditions of the Navy have been once more enormously enhanced, alike as regards the fitness of the ships, the skill and valour of officers and men, and the general behaviour under the most exacting conditions of everyone engaged.

As regards the relative losses of the two fleets there is nothing to add, so far as the British losses are concerned, to the first official announcement. But it may here be repeated that they comprise the battle-cruisers Queen Mary, Indefatigable, and Invincible, the armoured cruisers of the pre Dreadnought era Defence, Black Prince and Warrior, and eight torpedo-boat destroyers—the Tipperary, Ardent, Fortune, Shark, Sparrowhawk, Nestor, Nomad and Turbulent. Just as the German reports exaggerated our losses, so it is made clear now, beyond any shadow of doubt, that they greatly minimised their own. Admiral Jellicoe records that two battleships of the Dreadnought type and one battleship of the Deutschland type were seen to sink. A battle-cruiser was also sunk; this was admitted by the Germans, who recorded the loss of the Lutzow. One battleship of the pre-Dreadnought type and one battle-cruiser were "seen to be so severely damaged as to render it extremely doubtful if they could reach port." In view of the superiority of some of these units, the German losses in capital ships therefore equal in number and exceed in fighting value the British losses. In any case the proportion of losses of these vessels to the total strength of the German fleet is enormously greater than our losses relatively to our total fleet. Five light cruisers were "seen to sink." Admiral Jellicoe adds that "one of them had the appearance of being of larger type and might have been a battleship." As regards the small craft, six torpedo-boat destroyers were "seen to sink," and three others were "seen to be so severely damaged as to render it extremely doubtful if they could reach port." One submarine boat was also sunk. Thus in light craft the German losses were very considerably in excess of those of the British fleet.

When the enemy was first sighted, according to a semi-official appreciation of the battle, our Battle Fleet was to the North, and our Battle-Cruiser Fleet to the South. They were actually carrying out a combined sweep of the North Sea, and Admiral Beatty's fleet was in effect the observation or advanced squadron. The measure of the risk was the length of the period which must necessarily elapse before the Commander-in-Chief would be able to join the battle. When Admiral Beatty got contact at 3.30 p.m. with the German battle-cruisers they were proceeding northward; being inferior to his force, they turned southward. The inference was that they were either trying to escape or bent on leading him into danger. When such a doubt occurs there is in the British tradition a golden rule, and that is to attack "the enemy in sight." He engaged and continued to engage as closely as he could till he found the enemy's battle fleet coming North. At 4.40 he turned, but did not break off the action. The enemy in overwhelming force turned at 4.52, "but it was his duty to cling to them." For an hour and a-half the unequal battle raged, as Admiral Beatty and Admiral Evan Thomas led the enemy on, before Admiral Hood could appear with his Battle-Cruiser Squadron. The action—in line of battle steaming N.N.W.—was then at its hottest, but Admiral Hood, without a moment's hesitation, "and in a manner that excited the high admiration of all who were privileged to witness it, placed his ships in line ahead of Admiral Beatty's squadron. No Admiral ever crowned an all too short career more devotedly or in a manner more worthy of the name he bore." The risk was thus in a measure reduced, but there still remained the more delicate work of the Grand Fleet effecting its junction and entering the ill-defined action. The junction was effected with consummate judgment and dexterity. So nicely was it timed that the deployment was barely completed when at 6.15 p.m. the First Battle Squadron came into action with the enemy, who was already attempting to avoid action. They had fallen into the midst of the net which had been drawn about them. Unfortunately, however, there were hardly three hours of daylight left. Still our Battle Fleet was between the enemy and his base, and there would have been little hope of his escaping a decisive defeat but for the mist.

Sir David Beatty's courage in tackling the main fleet of the German navy with his battle-cruisers before our main fleet could arrive on the scene, and beginning action at 20,000 yards range, is brought out most vividly. As Sir John Jellicoe says, "the hardest fighting fell to the battle-cruiser fleet, the units of which were less heavily armoured than their opponents, the fifth battle squadron, the first cruiser squadron, the fourth light squadron and the flotillas." This was inevitable under the conditions, and the squadrons and flotillas, as well as the individual vessels composing them, were "handled with conspicuous ability." The Commander-in-Chief records his high appreciation of the manner in which all the vessels were handled. "The conditions were such as to call for great skill and ability, quick judgment and decision," and these were conspicuous throughout the day. As a commentary on the ludicrous claim of the German official reports, it is shown that first the cruiser squadron, and next the main squadron, got between the German fleet and its base, and it was only the extremely unfavourable light conditions which enabled the German fleet to escape into their harbour. The despatch is peppered with references to this unfortunate condition. One of our squadrons, for instance, when engaged with the enemy's light cruisers and eager to complete their destruction, was prevented by the mist from seeing the approach of the enemy's heavy ships, so that before they could withdraw they were caught under the heavy fire and disabled. It was in conditions like those that such vessels as the Black Prince were sunk. Again, "owing principally to the mist, but partly to the smoke, it was possible to see only a few ships at a time in the enemy's battle line. Towards the van, only some four or five ships were ever visible at once. More could be seen from the rear squadron, but never more than eight to twelve."

The action between the battle fleets lasted intermittently from 6.17 p.m. to 8.20 p.m., at ranges between 9,000 and 12,000 yards. The enemy constantly turned away, and opened range under cover of destroyer attacks and smoke screens as the effect of the British fire was felt. During the somewhat brief periods when the ships of the German high sea fleet were visible through the mist, the "heavy and effective fire kept up by the battleships and battle cruisers of the Grand Fleet caused the Commander-in-Chief much satisfaction, and the enemy's vessels were seen to be constantly hit, some being observed to haul out of the line. The enemy's return fire at this period was not effective, and the damage caused to our ships was insignificant." The German fleet appeared to rely very much on torpedo attacks, which were favoured by the low visibility, and by the fact that the main fleet had

arrived in the position of a following or chasing force. A large number of torpedoes were apparently fired, but only one took effect—on the Marlborough—and even in this case the ship was able to remain in the line and to continue the action. The enemy's efforts to keep out of effective range were aided by the weather conditions, which were ideal for the purpose. Two separate destroyer attacks were made by the enemy. The night attack by destroyers forms a record of many gallant deeds. The destroyer flotillas surpassed the very highest expectations that Sir John Jellicoe had formed of them.

Full justice is done to the engineering as well as other *personnel* of the Fleet in the despatch. In a former article we referred particularly to the importance of speed, and Sir John Jellicoe alludes to the rapid rate at which the Main Fleet was brought upon the scene on receipt of the information that the enemy had been sighted. During the two hours that elapsed from the receipt of the information the steaming qualities of the older battleships were severely tested. "Great credit is due to the engine-room department for the manner in which they, as always, responded to the call. The whole Fleet maintained a speed in excess of the trial speeds of some of the older vessels." But the whole *personnel* acted "entirely beyond praise." "On all sides it is reported to me," says Sir John, "that the glorious traditions of the past were most worthily upheld; whether in heavy ships, light cruisers or destroyers, the same admirable spirit prevailed. Officers and men were cool and determined, with a cheerfulness that would have carried them through anything. The heroism of the wounded was the admiration of all. I cannot adequately express the pride with which the spirit of the Fleet filled me." Again the Commander-in-Chief refers to the engineers, pointing out that it must never be forgotten that the prelude to action is the work of this department, and that "during action the officers and men of that department perform their most important duties without the incentive which a knowledge of the course of the action gives to those on deck. The qualities of discipline and endurance are taxed to the utmost under these conditions, and they were, as always, most fully maintained throughout the operations under review. Several ships attained speeds that had never before been reached, thus showing very clearly their high state of steaming efficiency. Failures in material were conspicuous by their absence, and several instances are reported of magnificent work on the part of the engine-room departments of injured ships. The artisan ratings also carried out much valuable work during and after the action; they could not have done better." Sir John further bestows recognition on many of the officers, and, as regards Sir David Beatty, says that once again he showed "his fine qualities of gallant leadership, firm determination and correct strategic insight. He appreciated the situation at once, on sighting first the enemy's lighter forces, then the battle-cruisers, and finally his battle fleet. I can fully sympathise with his feelings when the evening mist and failing light robbed the fleet of that complete victory for which he had manœuvred, and for which the vessels in company with him had striven so hard." In fact, everyone, in whatever type of ship, must have experienced the keenest disappointment, especially when on June 1, they searched amidst the mists for the remainder of the German fleet, and realised that under a most effective envelope of clouds they had been able to scuttle back—a crippled fleet and demoralised *personnel*—to their well-mined base.

As the Lords Commissioners of the Admiralty state in a letter to the Fleet, "the results of the action prove that the officers and men of the Grand Fleet have known both how to study the new problems with which they are confronted, and how to turn their knowledge to account. The expectations of the country were high; they have been well fulfilled."

POISONS USED IN THE RUBBER INDUSTRY.

SCIENTIFIC inquiry and recent legislation have alike taught the economic truth that the human element in industry is of great practical importance. In days when competition exercises a severe pressure in every direction, it is recognised that the health of the skilled and intelligent operative class is a deciding factor in determining output and consequent prosperity. The effect of environment on the living machine is no longer ignored, for the ready response made to the changes in the condition under which that machine works is everywhere acknowledged. The spread of exact information is therefore most desirable both on behalf of the employer and the operative. On this account, the brochures published by the United States Bureau of Labour Statistics, indicating judicious methods of controlling operations that are injurious to health with the view of securing an improved hygiene, are deserving of wide publicity. The latest* to come before us is by Dr. Alice Hamilton and has reference to the poisonous effects of the dusts and fumes due to the use of various chemicals in the rubber industry. In the arts and sciences, rubber finds wide application, but its treatment is still in an experimental stage. Numerous substances are being tried for compounding and curing the raw material, and the deleterious character of many of these is very imperfectly known and recognised by workshop foremen and those engaged in the trade. Dangerous processes that under proper control could be carried on with impunity are often conducted with such carelessness that they become injurious to public health, and, owing to ignorance of symptoms by the employees, and imperfect information given to the medical staff, industrial poisoning may occur without the authorities being aware of the cause. Publicity and discussion are therefore desirable, since those who are liable to suffer will be enabled to insist on the adoption of remedial machinery, while those who are anxious for the welfare of the operatives will provide a more efficient protection.

Dr. Hamilton's experience is wide: she visited some 35 factories scattered over a large area, and saw not only the conditions under which the men were working, but interviewed those who were responsible for operating the special appliances provided. The personal element is of profound importance in giving effect to precautionary measures, for the best palliatives are valueless if used unintelligently. The need for precautions is everywhere admitted, but the enforcement of a definite practice is faulty. Dust is allowed to accumulate unnecessarily, hoods and exhausts provided for the removal of gases and vapours have insufficient draught, and receptacles that are intended to be kept closed are left uncovered, but in the main, lighting, ventilating, and physical surroundings were found to be satisfactory. Immunity from the grosser forms of industrial disease has sometimes bred indifference to necessary precautions, and genuine ignorance of the nature of the poisonous substances is responsible for some of the carelessness exhibited. But when, as in a case cited, a foreman declares that he did not know that litharge was a form of lead, he is probably trying to hide faults of negligence under a cloak of assumed ignorance. Some processes are trade secrets, jealously guarded, and the chemicals used are naturally unknown. Such secrets are more generally connected with reclaiming processes for recovering rubber from scrap, and in default of precise details no further mention will be made of this branch of the industry.

The first process of importance into which poisonous ingredients may enter is that of vulcanisation or the incorporation of sulphur into rubber for the purpose of hardening it and rendering it less adhesive. The operation is effected in various ways, the most usual in the United States being to mix sulphur with the crude rubber and apply dry heat or steam, with or without pressure. The monochloride of sulphur can be applied either in a vapour form, or mixed with some solvent of rubber, as benzol, to make penetration more rapid. Some accelerating process is especially desirable when dry hot air is used, and it is through the introduction of various chemicals to promote combination that any injurious effect on the health of the operator can arise. The most common accelerators are salts of lead, particularly litharge; sublimed lead, which is an oxysulphate, is also used, and, less frequently, the basic carbonate and red lead. There is an increasing tendency for aniline oil to be substituted for litharge, presumably because it is thought to be less dangerous in use. Antimony pentasulphide is also used, particularly when it is desired to colour the finer grades of red rubber. Lead oxysulphate is not so soluble in the human stomach as litharge, or white lead, but it is a light, fluffy material, that careless handling can diffuse in the air with disastrous results. Being less known than litharge, its properties are less suspected among workmen, and it is needful to insist that the handling and weighing of this sublimed lead should be effected under a hood with an exhaust. The physiology of the absorption of aniline oil, a mixture of amidol-benzol, toluidine, and other ingredients, in the human body has not been so well studied as lead poisoning; but there is no doubt that the oil as used commercially is a dangerous volatile poison, that affects the nervous system and acts destructively on the red blood corpuscles. The diagnostic signs are pallor, the countenance assuming a bluish colour, especially in the lips, though the familiar blue line on the gums, characteristic of lead poisoning, is apparently absent. With continued exposure to the fumes, loss of consciousness supervenes, occasionally prolonged to a dangerous extent. There is no irritating effect on the eyes and the mucous membrane, which, in the case of most volatile poisons, acts in some measure as a preliminary warning. Owing to the preparation of aniline from nitro-benzol having been mainly in German hands, the medical profession has had little opportunity of studying or of extenuating the danger attending its use; but at Akron, in the early days of manufacture, before the peril was fully appreciated, one physician stated that he had seen over 100 cases of aniline poisoning. This is a large number considering the limited character of the employment, but the percentage of attacks is more clearly indicated by German writers, who state that in one factory 11 men out of 17 were poisoned, two of whom were carried unconscious to the hospital. Another feature marking the peculiar toxic effect of aniline oil is the rapidity with which the poison can work. Two cases are reported from the Zeiss Optical Works, in which one operator was attacked after an exposure of two hours, and another after four hours to quite small quantities of the oil vapour. In another case cited, a workman was unconscious for nine hours after having spilt a can of the liquid over his clothes. Since we are anticipating a considerable increase in chemical industries after the war, it behoves us to take note of the sources of unsuspected industrial poisoning.

Antimony, whether in the form of pentasulphide or tri-sulphide, is another poison which has passed nearly unsuspected, except by trained toxicologists. A harmless character has been imputed to it from its slight solubility, but close study has shown that when absorbed into the system it can give rise to dysenteric attacks, wasting, weak heart, albuminuria and glycosuria. A careful test carried out by Dr. Carlson, of Chicago, at the instance of Dr. Hamilton, proved that the antimony sulphides as handled by workmen in the rubber industry are soluble in the digestive juices to a recognisable extent, producing chronic antimonial poisoning. From the samples of antimony experimented upon the "crimson" is apparently more injurious than the "golden" or pentasulphide, in the ratio of about 3: 1; and this is so far fortunate, as the golden is more used; but the reckless manner in which either is handled constitutes a very real danger to the operatives.

When the rubber, by compounding and mixing, is fitted for the manufacture of special articles, the workman may be brought into contact with other toxic and deleterious substances in the form of solvents. Among the more common are the petrol products of naphtha, gasoline, and benzine, to which must be added coal-tar benzol, carbon disulphide and carbon tetrachloride, all of which are employed in the production of rubber cement. Actual experiment on the human subject shows that the petroleum products when administered in quantities varying from 5 to 15 grams cause in most subjects dizziness, nausea, vomiting, injection

* "Industrial Poisons Used in the Rubber Industry." By Alice Hamilton, A.M., M.D. Industrial Accidents and Hygiene Series. Washington: Government Printing Office, 1915.

of the conjunctiva, burning sensation in the throat, and always drowsiness. A curious feature is the varying degree of susceptibility exhibited by different individuals. This varying tolerance may have led to some doubt whether there is any recognisable form of chronic benzine poisoning. The workpeople are themselves aware, however, of certain curious effects, traceable to its actions, known among them as "naphtha jag," whose symptoms are displayed in irresponsible conduct and unreasonable behaviour. Exhaustion and complete unconsciousness will supervene on long exposure to the fumes.

Coal-tar benzol, though capable of producing violent acute poisoning when the fumes are inhaled, is not used to such an extent in rubber factories as to give rise to typical symptoms, though fatal cases have been reported. Just as females are more adversely affected then males by lead, so with benzol, all the reported fatal cases being girls who have handled a solution of rubber in crude benzol. Death resulted apparently from respiratory paralysis.

Carbon disulphide and tetrachloride are poisons used not only for solvents, but occur very widely in well-known processes, by which sulphur monochloride is compounded with crude rubber. It is the extensive use of carbon disulphide that has caused the rubber industry to be ranked as a dangerous trade. Nervous diseases resulting from inhaling the fumes of carbon disulphide have been so pronounced that the form of poisoning has come to be regarded as the typical rubber-workers' disease. Fatal cases are rarely met with, or reported, because death may occur long after attack. The usual symptoms are manifestations of excessive exaltation of the nervous system with slight delirium. Sir Thomas Oliver described a factory in which the windows of the vulcanising room were kept barred, to prevent acutely poisoned men from leaping out during attacks of mania. The frequent repetition of such attacks cause general debility, and at the end of a few years' work the workmen are degenerated both morally and physically, becoming quite incapable of earning a livelihood. So prevalent were the effects among workers a few years ago that in the Leipzig asylum at one time there were no less than 50 cases of carbon-disulphide insanity. Some recover, but incurable dementia is the fate of a great number. If, as some French doctors hold, carbon disulphide is not the real and primary cause of nervous derangement, but only the exciting cause of hysteria in people already predisposed to it, some improvement might be effected by a more careful selection of workers. The experience of a few weeks or months is usually sufficient to decide susceptible cases, so that the possibility of making an early discovery that would prevent development into permanent crippling disorders is not altogether excluded. Of course, the universal panacea, improved ventilation, has been invoked, but the beneficial effects of ventilation are strictly limited. In many plants, after spending money on an elaborate system of ventilation, the air has been too hot or too dry, or too moist, and the effect on the industrial efficiency of the individual has been practically negligible. There is, however, some evidence from experiments conducted by German authorities that no appreciable trouble was experienced when the amount of fumes in the air was less than one milligramme per litre. With increased fumes, clouding of mentality, headache and dizziness became noticeable, and serious symptoms developed rapidly when the quantity present reached 3.5 milligrammes per litre.

Carbon tetrachloride has been introduced as an alternative to the disulphide, on account of its less inflammable, and supposed less poisonous, character. Having been little used in industry, its qualities are less known, but the good reputation it enjoys is scarcely warranted. As might be inferred from its molecular construction, it is capable of affecting the workers with symptoms akin to those produced by chloroform; indeed, its suspicious character is confirmed mainly from the experiments of those who have tried it as an anæsthetic, and abandoned its use, having proved it to be more toxic than chloroform. In rubber factories it is still on its trial, but as it is more expensive than carbon disulphide, and slower in its solvent action, it is not likely to have a long life. Dr. Hamilton found it in use in only three factories, and the complaints of the workmen are too few and insufficiently precise to determine its baneful character.

This list of the main poisons in use is not complete, because of the various secret processes that are carried on. There is reason to believe that large quantities of phenol of various degrees of crudeness find employment. Poisoning may result either from the inhalation of fumes from these phenols or from absorption through the skin when exposed to solutions. The phenol group have as a common characteristic their excretion by the kidneys, and in severe cases this derangement may lead to chronic nephritis, eventually causing death.

The deadliness or unhealthiness of a poison will depend much upon the manner in which it enters into the several operations. A distinctly venomous character may serve as a protection, for precautions must then be taken to render it innocuous. In the insidious character of the rubber poisons lurks much of their mischief; they are too easily tolerated and little is done to reduce their effect to a minimum. In many of the operations improvement might be easily effected if the danger were more fully appreciated. For instance, in the process of vulcanisation where heat curing is adopted, though lead in some form is used, the risk to health is far less than with the acid and vapour form of curing. By care, the evils inseparable from lead usage can be nearly eliminated, but it is difficult to escape from the vapour of carbon disulphide which enters into that method of vulcanisation which is unfortunately the cheapest in labour and equipment. Again, in "mixing," the danger to the workpeople can be reduced by placing hoods over the mills to catch the dust, but oftentimes the hoods are placed too high and the exhaust is too slight to act with efficiency in carrying off the dust. This impalpable dust follows the rubber worker through all his operations, and its irritating effects are ever with him. In every process of manufacture, from the time of compounding and mixing the ingredients till the old rubber is ground up for shoddy, the workman seems to breathe an atmosphere of dust. It may be only starch or pumice, intended to make moulded goods keep their shape, or prevent such articles from adhering when heated. But there is so much of it, good form seems to demand that men and women alike should be coated with it, that escape from its disagreeable, if not injurious, effects is impossible. The evil could be materially reduced. Much of the work might be done in well-closed machines or under dust-tight covers, but the conservatism of the workman resists such innovation.

The usefulness of such an investigation as that conducted by Dr. Hamilton is in preparing the way for preventive measures on intelligent, well-considered lines. In the past, with the best of intentions, legislation has not always been well directed or produced the best return from the machinery set up. The pressure of public opinion, or agitation by mistaken enthusiasts, has induced unscientific legislative bodies to enforce regulations neither wise in conception nor thorough in their reform. Careful inquiry should precede legislation; it too often follows it; and it must not be assumed that a process of combating disease in one industry will be effectual because it proceeds on traditional lines that have met with success in some other particular direction. Dr. Hamilton has placed us in possession of a considered statement in which facts and statistics are exhibited without prejudice or bias. This impartial survey should serve both as a safeguard against misdirected and uninformed enthusiasm, and as a guide to the adoption of measures that would prove of material advantage to an important industry, and have a beneficial influence on the public health.

THE FRENCH STATE RAILWAYS.

WHEN dealing, in a recent article, with the French railway companies, and with the influence of the war upon their working and receipts,* we remarked that it was not possible for us at the time to give comparative figures for the French State-owned railways—*i.e.*, the older State railways with main lines from Paris to Bordeaux and serving the South-Western districts of France, and the newer, or nationalised Western of France system. The two together have a total developed length of about 9000 km. (5600 miles); they are worked by State officials, and the results they have hitherto given, both in regard to finance and to meeting the needs of the districts and population served, cannot be considered satisfactory. The State Railways published almost simultaneously a short time ago the reports for both 1913 and 1914; their report for 1913 appeared at the time when the private railway companies were issuing their report for 1914. In order to compensate somewhat for their delay, the State Railways issued their own report for 1914 very shortly after that for 1913.

A Socialist member of the French Parliament is reported to have said that: "if the Western Railway of France had not been nationalised a number of military manœuvres which saved the country would have been impossible of execution." The statements made and the figures quoted in our former article above referred to, dealing with the French private railway companies, afford a proof of what these companies have done in the emergency to further the national cause. No objection can be raised to the statements made in the State Railway report for 1914, to the effect that the formation and running of trains, consisting of a large number of vehicles destined for the carriage of covering forces, were effected in satisfactory conditions, that numerous special trains were run from important centres for the conveying of other forces, and that from the second to the eighteenth day of mobilisation 1186 were run for distributing a number of army corps. But the privately-owned railway companies have also contributed, and are still contributing in satisfactory conditions, their full share to the work of national defence. Like the private railway companies, the State Railways gave the nation the full aid they were able to give; the State Railways might, perhaps, have done still more than they did, for it would appear from an official report that towards the end of July, 1914, when diplomatic tension was gradually increasing, a number of engines had rapidly to be put in good running order, and in the different depôts men were working day and night to render available for immediate service in case of mobilisation the largest possible number of heavy locomotives. Further, rolling-stock had to be hastily concentrated at parts of the system where the figures had been allowed to fall below the military standard; military platforms and embarking stations had also to be put in good working order, which allows the supposition that they had not been maintained in the required normal condition. For some time past, the strengthening of the Eusplet viaduct, near Rouen, had been imprudently delayed, with a view, it is surmised, to decrease the figures on the debit side of the State Railway accounts; it is owing to the insufficient strength of this viaduct that delay has occurred in running the large engines of the "Pacific" type, purchased at a high cost several years ago for the Havre rapid service. When mobilisation took place, the heavy military trains were not allowed to travel over the viaduct; they had to travel to their destination in a roundabout way.

Many complaints were raised in the French Parliament and Press towards the end of 1915, and at the commencement of the present year, in regard to the most inadequate service given by the State Railways, and we need not enlarge upon this point. At the same time these railways dealt with a large amount of military traffic, but so did the private railway companies, and we have not seen that these private companies have been called to account for lack of commercial transport facilities to the extent that the State Railways have been. In considering the situation between the two, the fact should not be lost sight of that the State Railways placed at the disposal of the military authorities a large number of men—there being at one time with the Colours as many as 18,000; on the other hand, the State Railways have always had a much larger staff than that of a private railway company. In point of fact, the French Minister of Public Works announced officially not long ago that no French railway system had such a numerous staff as the

* See ENGINEERING, vol. c., page 646.

State Railways. The men taken from the latter railways were gradually replaced in part by refugees from the Belgian railways and by men formerly employed in the invaded districts served by the French Northern and Eastern Railways. The State Railways were very ill-advised when recently they argued upon lack of rolling-stock to explain their inability to cope with the nation's commercial needs, since besides their own rolling-stock and 1000 wagons they hired from the auxiliary rolling-stock company, they had at their disposal 15,000 wagons from the Belgian railways, the French Eastern and Northern Railway Companies; the Paris-Lyons-Mediterranean Company also handed over to them 2600 wagons which that company had received from the French Eastern Company.

The official report on the working of the State Railways in 1913 showed some improvement on the figures for 1912; it should be remarked, however, that 1912 was a very bad year. On the older State system, nationalised in 1878, the gross receipts in 1913 were about 72,000,000 fr. (2,880,000*l.*), and the working expenditure about 62,000,000 fr. (2,480,000*l.*). In this latter total, 4,300,000 fr. (172,000*l.*) fell to the central staff; 14,200,000 fr. (568,000*l.*) to the staff of the traffic department; 11,240,000 fr. (449,600*l.*) to that of the rolling-stock and locomotive department; and 5,170,000 fr. (206,800*l.*) to that of the permanent-way and buildings department. These four last sums expended on the staff make a heavy total. The charge on capital in the case of this, the older system was put down at the low sum of 1,233,000 fr. (49,320*l.*), and in this respect the Board is said not to have acted at all fairly for the last 35 years. The Board, on their part, claim that hitherto they have been unable to introduce into their accounts the actual charges on capital, since they have not yet been able to arrive at the amount of the capital itself. It is stated, on the other hand, that a Special Commission has of late worked out the figure in question, but that this is not made public, no doubt, it is added, because it is found too high and would entail very heavy charges which would more than swallow up the excess of receipts over expenditure, or, in other words, the apparent profit, which for many years has been quoted as being the actual profit. The accounts of the State Railways, it is repeatedly said in France, are drawn up with a view to conceal liability and to show an excess in receipts in place of a notable annual deficit. This, it is added, applies also to the year 1913, in which the purely fanciful excess of receipts over expenditure is shown to exceed the corresponding figure for 1912 by 3,380,000 fr. (135,200*l.*). It should be noted here that in 1913, in order to cover extraordinary expenditure, recourse was had to an issue of 15,000,000 fr. (600,000*l.*) of redeemable bonds and to advances by the Treasury to the extent of 38,000,000 fr. (1,520,000*l.*). Further, the indemnities for loss, damage, and for delays, negligence, and theft, traceable to the staff, give a total of 1,125,000 fr. (45,000*l.*), or a decrease of 550,000 fr. (22,000*l.*) on the corresponding figure for 1912. The progression shown for the receipts is really a low one and does not correspond to the improvement carried out for several years at stations, to the increase in rolling-stock and to all other work, making a total of 21,000,000 fr. (840,000*l.*) since 1909, and for which 31,000,000 fr. (1,240,000*l.*) were asked for in 1912, all of which expenditure was to result, so it was announced, in an increase of traffic and in larger total net receipts.

The net receipts for 1913 are really below the figure for 1910 by 750,000 fr. (30,000*l.*). The ratio of working expenses to gross receipts is below the extraordinary figure for 1912, which far exceeded 91 per cent., but it exceeds by over 3 per cent. that for 1910. In 1913 it exceeded 86 per cent. The high ratio is due, among other things, to an excess of staff.

In regard to the newer State Railway system—*i.e.*, that formerly owned by the Western of France Company and which was nationalised because, so it was argued, its operation by the company was too onerous, its working by the State is much more onerous still. The length worked is about 6000 km. (3730 miles), and for 1913 the receipts have been slightly under 252,500,000 fr. (10,000,000*l.*), and the expenditure 215,000,000 fr. (8,600,000*l.*). In this latter total there are 15,500,000 fr. (620,000*l.*) for the central staff; 57,000,000 fr. (2,280,000*l.*) for the staff of the traffic department; over 39,000,000 fr. (1,560,000*l.*) for that of the rolling-stock and locomotive department; and 16,000,000 fr. (640,000*l.*) for that of the permanent-way and buildings department. If the charges on capital be taken into account, a deficit is arrived at of about 75,000,000 ft. (3,000,000*l.*). This new State Railway system carries on business without regard to economy, since in the year 1913 it spent 225,000,000 fr. (9,000,000*l.*), which it obtained partly by an issue of redeemable bonds, for 85,000,000 fr. (3,400,000*l.*), 140,000,000 fr. (5,600,000*l.*) being advanced by the Treasury. The works which these sums were intended to cover were far from being all necessary; the ambition, however, is to make the system a model one from the point of view of the conditions of working—technical conditions of working if not financial ones—a result which was not reached in 1913, nor again in 1914. The net receipt surplus, without taking into account the charges on capital, was about 72,000,000 fr. (2,880,000*l.*) per year during the last years, when the same system was worked by the Western of France Railway Company. As soon as the State took the system in hand, this figure fell to 66,000,000 fr. (2,640,000*l.*), then gradually down to 28,000,000 fr. (1,120,000*l.*). The figure of 37,500,000 fr. for 1913, although higher than those for 1911 and 1912, is, as will be seen, far below the last figure yielded by the company's working. The ratio of operating expenses to gross receipts of the private company was 67 per cent. only, as against 85 in 1913 and 88.6 in 1912, besides which the State, in its system of account-keeping, throws back to the Western of France Railway Company a series of items of expenditure which, it claims, are arrears that should come under the company's account. In the operating expenses, the indemnities for losses, damage, delays and accidents yield a high figure, less high, it is true, than in 1912 or 1911, because an attempt has been made to put a stop to negligence on the part of the railway staff. Notwithstanding this, the indemnities for losses, damage and delays gave a total of 3,500,000 fr. (140,000*l.*), and the accidents cost another 2,000,000 fr. (80,000*l.*).

It will easily be surmised that the war must have had a very detrimental effect upon railway systems which in peace time were worked in indifferent conditions. On the 3038 km. (1880 miles) of the older system the train circulation for 1914 decreased enormously. The gross receipts were barely 67,000,000 fr. (2,680,000*l.*), whilst expenditure amounted to over 61,000,000 fr. (2,440,000*l.*). The ratio of operating expenses to gross receipts, high in peace times, reached in war time over 91 per cent. Moreover, in 1914, as in 1913, the whole of the actual charges upon capital for this older State system are not given in the accounts; a low figure only is included in reference to bond issues. The war has greatly reduced the commercial traffic of the system. The number of passengers carried fell from 16,740,000 in 1913 to 13,400,000 in 1914, the mileage run rising from 44¼ to 46 km. (27 to 28.5 miles). The average receipts per passenger rose from 1.25 to 1.34 fr. (from about 1s. to about 1s. 1d.), the average receipts per kilometre falling from 0.0283 to 0.0189 fr. (0.45d. to 0.3d. per mile), figures which point to a lower proportion of runs at a reduced fare and to the exodus of the population towards centres at a distance from the scene of hostilities. The total freight carried by goods trains fell from 6,559,000 tons to 5,378,000 tons, showing a decrease of 18 per cent.; the tonnage carried per kilometre showed a decrease of 20.4 per cent.; the mean distance carried per ton fell from 121 to 117.5 kms. (75 to 72.9 miles), and the average receipts per ton from 5.74 to 5.60 fr. (4s. 7d. to 4s. 6d.). In 1914 the war transports yielded receipts to the amount of about 6,000,000 fr. (240,000*l.*).

The length of the newer State Railway system, the nationalised Western of France Railway, in service in 1914 was 6040 km. (3750 miles). The gross receipts amounted to about 230,000,000 fr. (9,200,000*l.*), and the expenditure to 195,500,000 fr. (7,820,000*l.*), the apparent net receipts being about 34,500,000 fr. (1,380,000*l.*). The ratio of operating expenses to gross receipts was 84.90, or 0.27 per cent. below the figure for 1913. The working expenses were reduced in a marked degree, owing to the train traffic having fallen considerably from the opening of hostilities down to the close of 1914. The local trains numbered over 1100 in July, 1914; in August following this number was brought down to 500, and at the end of the year it increased to less than 600. The main line trains of the two State Railway systems fell from 1975 in July, 1914, to 550 in the first days of August following, and hardly exceeded 1000 at the close of 1914. It would appear that such a reduction in the number of trains should lead to a reduction in expenditure. The military transports on the newer system led to receipts amounting to 28,500,000 fr. (1,140,000*l.*) for 1914. Notwithstanding the great reduction in operating expenses, the debit balance is close upon 84,000,000 fr. (3,360,000*l.*) in 1914, in excess of that for 1913.

The passenger receipts in 1914 having been about 85,500,000 fr. (3,420,000*l.*), they show a decrease of about 18,500,000 fr. (740,000*l.*); the receipts for freight traffic totalled 87,000,000 fr. (3,480,000*l.*), showing a falling off of 25,500,000 fr. (1,020,000*l.*). On the other hand, the staff expenditure fell less than 2,000,000 fr. (80,000*l.*). Much less has been spent than formerly on renewals, repairs and maintenance; this, at best, is not a real saving.

As pointed out above, when dealing with the unfavourable results lately given by both the older and the newer State Railway systems, it is necessary to take into account the most particular circumstances which ruled in 1914. But, as we have pointed out also, matters were in not much better condition in 1913. In point of fact, and more specially in regard to the nationalised, newer system, which formerly belonged to the Western of France Company, this system has given worse and worse results ever since it was taken over by the State. It is now operated, according to French accounts, with much less care and at an increased expenditure compared with the former working by the company.

NOTE.

MONOCHROMATIC PHOTOGRAPHS OF JUPITER AND SATURN.

WHEN describing "Recent Experiments with Invisible Light"* before the Royal Institution in 1911, Professor R. W. Wood, of Johns Hopkins University, Baltimore, exhibited some photographs taken in infra-red light—which he had been studying with Professor Rubens in Berlin—and in ultra-violet light. Those photographs brought out very peculiar differences, much more striking sometimes than the contrasts in apparently uniform tints revealed by illumination with sunlight and with electric light. Photographed in infra-red rays the sky and landscapes looked black, the grass white, shadows were pronounced; taken in ultra-violet light the sky was whiter than white paper, and a man threw no shadow in full sunlight. Forgeries made with different inks were at once detected, and the rocks of the moon craters lost their uniformity. Professor Wood studied the reflection of different monochromatic rays from various rocks in this connection. From a communication published in the *Astrophysical Journal* of May, 1916, it does not appear, however, that he has continued these interesting researches except with respect to taking photographs of the planets Jupiter and Saturn. The preparatory experiments were made at the Princeton Observatory, with the aid of a coelostat and a horizontal reflecting telescope. The silver mirrors were nickel-plated (by electrolysis of nickel fluoborate), because silver is a very poor reflector for certain ultra-violet rays. To photograph in ultra-violet light, the light was filtered either through quartz or uviol glass covered with a film of silver (likewise nickelled over), or through glass cells in which a few drops of bromine were evaporated before closing the cell. These bromine cells, 5 cm. in thickness, cut off all rays above 3,500 Angström units, and require much shorter exposures than silver films, which, moreover, have a selective absorption for the range 3,200 to 3,000 A.U. For a more restricted use of particular ultra-violet light very diluted solutions of potassium chromate, barely yellow in colour, were used. The filters for the other radiations were gelatine films of the

* See ENGINEERING, vol. xci., page 698, May 20, 1911.

Eastman Company, the infra-red screen transmitting rays above 7,000 A.U., the yellow screen rays above 5,000, and the violet rays between 4,500 and 4,000 A.U. The final experiments were made in the Mount Wilson Observatory, where the 60-in. reflector was placed at Professor Wood's disposal for four nights of October, 1915. The results obtained are of great interest, though the reproduced photographs at first sight may only appear to differ as to definition. In the yellow light Saturn—which was in a favourable position, apparently floating in its rings—appears much like the astronomer sees it, with its rings and narrow belts parallel to the equator. The infra-red light photograph is less distinct. In the violet light a dark equatorial belt and a dark polar cap become quite plain, which are less distinct again in the ultra-violet light. The violet photograph, moreover, shows the portion of the sky enclosed between the ball and the rings of the planet darker in shade than the sky outside the rings, and there were also differences in brightness between the different rings and the ball. These appearances might be explained by assuming the rings and the space inside them to be filled with dust or gases differing as to scattering or absorption, and this assumption received a certain confirmation by observations taken with slit spectrographs; but the observations are not all in concord. Jupiter presented much the same variety of phenomena. The violet rays bring out most detail, narrow belts (all parallel to the equator) being distinguishable on these photographs, which are not, or hardly, noticeable on the other photographs; the polar caps can be seen on all the photographs. On the other hand, the yellow light best shows the spotted character of some of the belts. The exposures used were 2 seconds for yellow and for violet, 7 seconds for ultra-violet, and 9 seconds for infra-red light The eight photographs were taken between 7.30 and 9.30 p.m., and the telescope had to "follow" the planet very regularly. The trichromatic positive transparencies which Professor Wood obtained from the yellow, violet and ultra-violet negatives are exceedingly interesting. Saturn came out yellow with an orange equatorial belt, an orange polar cap, and fainter bluish belts between them; the inner ring appeared white, the outer bluish-green. Jupiter showed belts and polar caps of similar colours.

A 440 MILES ELECTRIC RAILWAY.—For a distance of 440 miles (more than the distance between London and Glasgow) the Chicago, Milwaukee and St. Paul Railway has been electrified, the first unit of 115 miles being already in actual operation. The full East-to-West sweep of the Rocky Mountains is traversed, and the electrical line runs across the three principal mountain ranges. Under normal conditions 42 electrical locomotives are required to haul freight and passenger trains over the electrified portion of the railway. Each of these locomotives measures 112 ft. 8 in. in length, weighs 284 tons, costs approximately 25,000*l.*, and will haul an 800-ton passenger train on a level stretch at a speed of 60 miles an hour. The electrical energy required is obtained by water power. The entire work of electrification cost approximately 2½ millions sterling, and has required three years to complete. It was described in our issue of January 21, 1916. The European agents of the railway are Messrs. J. Jackson and Sons, 7, Charing Cross, London, S.W.

RAPID FILTRATION PLANT AT GREENHEAD.—The Irvine and District Water Board have just installed a rapid filtration plant capable of dealing with 5,500,000 gallons a day. This is housed in a building 136 ft. long by 38 ft. wide, placed alongside the existing slow sand filters. Behind the filter house is a tower which contains the gear for the preparation of the reagents used for the purification of the water. The supply is a soft moorland water, containing varying proportions of organic matter in suspension and having a brown peaty stain. This stain requires a coagulant for its removal, while a trace of lime is added to correct any plumbo-solvent tendency. The proportion of sulphate of alumina solution is regulated by a float acting in conjunction with a 4-ft. rectangular weir. The water then flows through mixing tanks into sedimentation tanks. These tanks allow one hour for the precipitation of the heavier impurities. There are ten open gravity filter units, each 24 ft. by 12 ft., with a total filtering area of 2,880 sq. ft. The filtered water discharges into inspection boxes lined with white tiles. The filter bed is cleansed by agitation with sterilised compressed air at a pressure of 5 lb. per square inch. The Water Scheme has been under the control of Mr. Gilbert Christie, engineer of the Water Board, and the contractors for the filtration plant were the Paterson Engineering Company, Limited, of India House, Kingsway, London.

LITERATURE.

The British Coal-Tar Industry: Its Origin, Development, and Decline. Edited by WALTER M. GARDNER, M.Sc., F.I.C. With illustrations. London: Williams and Norgate. [Price 10s. 6d. net.]

THE cataclysm of the war has compelled the examination of many unpleasant problems that in the piping times of peace were not allowed to ruffle the even tenour of our way. The doubts and fears of those who venture to express any dissatisfaction at the stagnant or decadent conditions of our markets are brushed aside as the whimperings of pessimists, or silenced under floods of irrelevant statistics, so anxious are we to be lulled in the somnolence of a false security. But for a long time past the small expansion in some branches of the chemical trade, compared with the rapid increase in Germany, has been a source of anxiety to those who had a comprehensive grasp of the whole situation. Of these various branches, none exhibited the effects of inanition and exhaustion more clearly than the coal-tar industry, and no division of the coal-tar industry disclosed the gravity of the situation more distinctly than the department of synthetic dyes and drugs. The war has dissipated many cherished hopes and shown the unreality of many a fool's paradise, but it has also done the service of making us conscious of the extent to which our unsuspicious attitude toward our sagacious, painstaking, and unscrupulous enemy has imperilled our textile industry, hampered our production of explosives, and curtailed our supply of valuable and necessary drugs. The study of the history of the conduct of the trade in synthetic dyewares, of its blighting influence on the production of madder and indigo, should convey useful lessons to both the politician and the student of industrial economics, and, further, when much of that history is told by the men who have fostered its infancy, watched over its development, and mourned its premature decay, the tale should arrest the attention of the chemical expert no less than that of the general reader. The collection of the material necessary for a complete review has been the object of the editor, Professor Gardner, and he has well performed his task. The epoch-making steps in the progress of discovery and technology stand out boldly and distinctly, indicating the lines investigation pursued. We can live over again the exciting times of a generation ago, when startling discoveries followed each other with such rapidity that masters, expert in explanation, were hardly equal to the task of translating the cryptic formulæ of the chemist into a language understood by the eager but unspecialised audiences that hung upon their words.

Underlying this history there is a more serious purpose than the pleasant tickling of our memories by recalling past triumphs in chemical science, or uttering unavailing regrets that the successes of the laboratory have not been preserved in the wider fields of manufacture. We have sown, but others have reaped the harvest; the rewards for skill and acumen properly belonging to our countrymen have not only gone elsewhere, but have been used to sap the foundations of our trade in other directions. No one can write or read without a sense of pain and humiliation that less than one-tenth of the annual value of dye-stuffs consumed in England is produced in this country. For the mischief due to incompetence or misguidance is not confined to a comparatively small trade, which perhaps does not exceed more than 2,000,000*l.* annually; the incapacity to hold our own against competition spells feebleness and decadence, that in the future will make the struggle for the possession of larger national interests harder and more uncertain. By allowing Germany to control the dye-stuff industry, we have not only jeopardised all manufactures in which the use of pigments enter, but we have enabled our astute competitors to train up an army of skilled workmen, to acquire enlarged experience, and from past profits to equip with machinery enormous establishments, by all of which we shall find ourselves severely handicapped in the coming struggle for supremacy. It is a clear duty to call attention to the numbing influence of the shackles we have forged for ourselves, to insist on more strenuous efforts from all concerned, to consider by what steps we can shake off the paralysing effects of lethargy and reconquer the leading position that belonged to us as pioneers—a far harder task than to retain what was once in our possession.

To make the campaign successful it is necessary to comprehend distinctly the causes that have led to our backsliding. This is not easy nor flattering to our self-complacency. Warnings have not been wanting in the past to tell us of the downward career we were pursuing; but these have been derided as voices crying in the wilderness, regarded with little import when the general trade of the country showed some increase from year to year. And perhaps the number of the reasons given for the relative decline here and the rapid growth in Germany, defeat the purpose for which each was exploited. This effect was not, as it should have been, cumulative, but mutually destructive. Singly each suggestion can be combated, and the supporters of some favourite theory look coldly upon the arguments of others, however anxious to secure the same end. Professor Gardner has brought the whole battery of criticism to bear upon an essentially weak position, but we cannot say that the stronghold of indifference and failure has been laid low, or decide on the effectiveness of each weapon of attack.

The reasons that have been assigned for the stagnation that overtook the coal-tar industry some fifteen years after its brilliant inauguration can be grouped into three classes, which may be described as scientific, fiscal, and social, and each finds many champions. Under the first head, it is urged that an insufficient number of chemists have been tempted to connect themselves with direct manufacture, that chemical research has been neglected, and that the older universities are blameworthy for not offering the same encouragement to science as to a purely literary education. Thirty years ago, Mr. W. H. Perkin, the discoverer of the mauve dye from which the manufacture of synthetic dye-stuffs took its rise, complained that our manufacturers neither employed nor appreciated the necessity of employing a sufficient number of chemists, and that such a career was made neither promising nor remunerative. Years later the same complaint of the indifference of manufacturers was repeated. Someone has said that a knowledge of the benzol market was held to be of more importance than a knowledge of benzol theory, and only last year Sir W. A. Tilden regretted how few were the manufacturers who regarded science in so serious a light that they provided in their works properly-equipped laboratories with a competent staff, whose occupation was not confined to analytical testing of materials or products, but extended to the systematic endeavour to introduce improvements into old methods or the discovery of new. It is to be feared that technical chemistry has been despised as a humble handmaid of theoretical chemistry, and the mistake of making a gulf between pure and applied science still operates balefully. On the other hand, Germany better understood the necessity of linking together industrial and theoretical chemistry, and, as a consequence, young men in great numbers have devoted themselves to chemical research, exhibiting enthusiastic and self-directed activities. The German was plodding and patient, content to wait in calm confidence for the rich reward that time would bring to him. Now when later events have shed a distressing light on German policy and character, we better comprehend the directing motive and the plan of action. We should understand the form of mind that prompted the German chemists, present at the Perkin Jubilee Dinner, to boast that they, and they alone, possessed the special aptitude for a class of research that demanded deep thinking as well as careful and patient application. With an amusing, but irritating, self-complacency, they regarded as a just and natural result the conquest of this particular industry, and its consequent gravitation towards Germany, as a crowning proof of German thoroughness and German intellectuality.

Not taking the German quite at his own valuation, there are those who do not accept this explanation as adequate or convincing. Our decadence

and incapacity are not so obvious or complete. But even admitting our inferiority and our inability to preserve and enlarge a trade that originated here, it is difficult to see how deterrent conditions, obscure and complicated as they are, can have operated co-incidently in other countries, as France, Italy, or the United States. It is necessary to extend the outlook and find other causes than improvident manufacturers, unambitious chemists, or an unsympathetic Government. Mr. Singer is one who will not accept the neglect-of-science explanation in its entirety, and puts forward another class of argument. He views the dye-stuff trade in its beginnings as crumbs which fell unheeded from the rich man's table and which the Germans were glad to lick up. It is true that in course of time the crumbs amounted to a very considerable loaf, but each contribution was small, and loftily disregarded. There may be now some 250 or 300 distinct products derived from coal-tar, but the output of the greater number of these is small, and the effect of accumulation has not been appreciated till too late. His contention is that in this country inventions are disregarded unless they relate to objects for which there is an ample market. Failing that condition of large demand, it is impossible to influence the manufacturing and capitalist mind. On that ground inventions are useless and disesteemed, and any increase in the numbers of inventors would be discouraged because opposed to an ordered conservative policy. Admitting the full force of such an argument, we fail to see how it applies to such inventions or discoveries as that of synthetic indigo, for which an immediate and large market existed.

Among the explanations classed as fiscal we meet with references to the operation of Free Trade and Protection. This is too large and thorny a subject to be discussed here, and no conclusion could be derived that would satisfy alike the advocates and opponents of long-established tariff policy. Foreign import duties, it is claimed, handicap our manufacturers and assist the foreign producer, since he can maintain his own prices at home, and at the same time dispose of his surplus production in this country, at or below cost price. The same argument applies to other wares, and we might expect that enterprise would be hindered and trade depressed, but similar disastrous consequences are not so apparent as in the coal-tar trade. The purchaser does not view the tariff restrictions in quite the same light as the producer. The different aspect makes decision difficult, and individual judgment must decide how far free-trade policy has been detrimental to expansion in this instance.

Several are loud in their complaints of the defective working of the patent laws. In the early days, it is alleged, and apparently with justice, that infringement was active and unashamed. Foreign manufacturers sold direct to the consumers, and as there were no duties, the Customs authorities gave no assistance, all colouring matter being declared under the name of vegetable dyes, and even when a case more glaring than usual was detected, it was well nigh impossible to prove that the suspicious articles were manufactured by the patentee's process. In Germany the patent laws were chaotic, each State having its own laws, and its own views on the method of their administration. The Germans, Mr. F. W. Perkin says, had the brains of the world at their disposal and had no fees to pay for their use. The moment a patent was published it was seized upon by the German firms without scruple or acknowledgment. Also, it is not obscurely hinted that the German spy system, whose wide-reaching tentacles have been felt so acutely of late, was actively working, and a system of "blocking patents" became an organised industry. The Patent Laws Amendment Act of 1907 is not viewed very favourably by experts. Many loopholes, it is asserted, have been discovered for evading the Act, with the result that is has not proved so helpful as anticipated.

Among the more trivial causes that have irritated the trade, and on which disappointment for the loss of profitable business is vented, but which under more healthy conditions would hardly be noticed, is the restriction the Government has placed upon the use of pure alcohol. It is true that, under pressure, the Government has made some concessions, and Sir W. Tilden states that the regulations are now comparable with those enforced in Germany, and that there is very little ground for complaint. On the other hand, it is contended that many manufacturers who have inquired into the new conditions have found the use of alcohol so edged and bound about with red tape and officialism that they are unable to take advantage of the privileges granted.

The third class of attempted explanations, which for want of a better term we have called "social," includes the disabilities erected by usage and character. We have already referred to the evil caused by considering technical chemistry as a kind of poor Cinderella among her more favoured sisters. In the same way, perhaps, all science to which the stigma of utility attaches stands lower in public esteem than do literary subjects. We have all heard of the university professor who rejoiced that his mathematics was of a kind that could not be prostituted to any useful purpose, and in this spirit of discouragement to industrial activity, the universities have done much to discredit the attractiveness of science. Professor Dewar, referring to the condition of chemistry at the end of the last century, said that at Cambridge "there was no such thing as a creditable chemical laboratory, that he himself was always ashamed when anyone asked to see the laboratory, because in truth there was none; it was in the same condition as it was a century previous." It is the newer universities that have done much to remove this mark of inferiority. But beside this brand of disapproval emanating from high authorities, the national character is rather inclined to rely on individual effort and exertion, not ill-pleased to plough a lonely furrow. Lord Justice Moulton, when addressing the makers of dye-stuffs at Manchester, said that he found his constituents so self-contained and reserved that each was firmly convinced that a tradesman's real competitor was the man who lived next door to him; nor could he be disabused of this false notion, which prevents all true co-operation and united systematic action. The German, when he shouts "Deutschland über Alles," is content to merge his individual interests in those of the nation; they all pull unanimously towards one goal, while we find our complete satisfaction in forwarding personal aims and profits.

That the coal-tar trade is placed in a very unsatisfactory position, and that the industries closely allied to it are jeopardised to a great extent, must be admitted, while, from the very variety of excuses or explanations offered the situation remains in doubt, preventing the application of any trustworthy remedy. The conclusion that will probably be formed from the perusal of this collection of the views of the most eminent chemists and economists of the day is that success depends on individual capacity, manufacturing skill, commercial enterprise, and intelligent co-operation, and that only by the harmonious working of these factors can we hope to escape the domination of the German dye-producing industry with all that is implied in the merciless application of the power acquired. We shall do well to remember the pregnant words of Sir James Dewar, uttered a dozen years ago: "To my mind the really appalling thing is that the German people have reached a point of general training and specialised equipment which it will take us two generations of hard and intelligently directed educational work to attain. It is that Germany possesses a national weapon of precision, which must give her an enormous initial advantage in any and every contest depending upon disciplined and methodised intellect."

Painting by Immersion and by Compressed Air: A Practical Hand-Book. By ARTHUR S. JENNINGS, F.I.B.D. Illustrated. London: E. and F. N. Spon, Limited. 1915. [Price 10s. 6d. net.]

THOSE whose acquaintance with the mechanical operation of painting has been confined to watching the slow, laborious method by which a painter, with brush and paint-pot, gives a coat of paint to some small object, will have a difficulty in crediting the degree of acceleration that has recently been introduced into the familiar manner of painting. As an example, we may cite the instance of an ordinary Ford motor-car, whose external surface can be completely and satisfactorily painted in the short space of two minutes. Mr. Jennings tells us that this is the regular time allowed, but, doubtless, this time could be reduced if the car had to be painted both inside and out. The object of the book is to trace the evolution of the processes that have made this economy of time possible, and to indicate some of the directions in which further improvements may be expected.

The displacement of the brush of hog's bristles by the process of immersion, or dipping the article to be painted into a tank of specially-prepared paint, was inevitable, though its accomplishment has taken many years to perfect. For rough agricultural implements, where decoration is of less importance than preservation, such a practice has long been in use. Improved methods, employing a much larger plant, have been adopted at Woolwich Arsenal, and may be briefly described, as these are more typical of the work of immersion as now practised. The success of the operations from an economical point of view is vouched for by the fact that the authorities have been able to reduce the number of painters employed in the proportion of 200 to 40. The object to be painted, such as a wagon, is brought alongside a tank of sufficient size to admit it being lowered into the paint, where it is allowed to remain for about half-a-minute. On being raised any great excess of paint runs off, at first into the tank over which it is suspended, and afterwards on an inclined floor, whence the extra paint is conducted, after filtration, back into the tank. An examination of the wagon is made during the draining process, and any obvious defects are at once remedied; it is then suspended on overhead rails that run round the building and slowly carried towards a second tank. By the time of arrival at this second tank the wagon is ready for another coat, and it is again dipped. Another draining, followed by another inspection, is all that is necessary, and the wagon is taken on rails to the drying-room, where it can remain till it is ready for use.

This process is obviously so simple, effective, and expeditious that one is surprised to find it rather a modern innovation, and one that has to fight against inveterate conservatism. The author, writing a practical book with the view of recommending the method, naturally discusses the objections that have been urged, and the causes of failure that have sometimes been reported. A fruitful source of disappointment lies, it is suggested, in experimenting with an unsuitable paint. No doubt the preparation of paint for this class of work needs, and has received, careful study by specialists, and the author's advice is sound in recommending the beginner to avail himself of the experience of particular firms. The features to be sought in a good dipping paint are freedom of flow and proper drip; sufficient binder to prevent chalkiness and produce a firm coat; covering capacity and an even distribution of the paint. With these qualities should be associated the power of drying hard in not less than six hours; the consistency should be such that only a minimum will run off, while it must not be so thick as to give rise to "tears" or "runs." Also it is desirable that the pigment should be of such a specific gravity that when mixed with a suitable vehicle or thinner, it will not quickly deposit at the bottom or settle out. As a rule, the plunging of articles into, and their withdrawal from, the tank will stir the paint sufficiently; but to ensure an even mixture paint-tanks are designed with paddles fixed at the bottom, that by turning rapidly in opposite directions keep the paint in constant agitation. Such paddles have the advantage that they permit the paint paste to be thinned down by the use of benzine or some petrol preparation, as "white spirit," to such a consistency as the nature of the work may require.

The process of varnishing can be effected in the same way as paint dipping, and is successful in proportion to the care bestowed upon handling and dipping the goods. In a well-appointed factory it is contended that the finish approaches perfection, while the time and labour required are materially less than in the old process. Dust is a trouble against which it is necessary to be on one's guard, but the same difficulty occurs in brush-work,

and the time during which protection is required is longer. Air, which is admitted for ventilating, should be strained before entering the room by being passed through cotton-wool, or some such filter. Other precautions will easily occur to experts who are specially alive to the necessity of preventing draughts, liable to give rise to "blooming," an unsightly deposit that mars the appearance of the work. The author is well advised in directing attention to such details while urging the adoption of comparatively new methods. The plan of dipping is not suggested because it eliminates all the defects of older operations, but because, without increasing these defects, it has undoubted merits of its own. Many a precaution that is submitted to uncomplainingly when following routine processes becomes an irksome burden when its use is novel and unpractised. But the difference between success and failure depends on the exercise of proper care at the outset, and it is to be feared that some of the objections that have been raised to the use of speedier methods of painting and varnishing arise from the neglect of due precautions, and an unwillingness to travel out of the course prescribed by long custom.

The plan of depositing paint from a spraying nozzle, through which air is forced at considerable pressure, is more ingenious than that of dipping, and requires more training and skill on the part of the operator. For these reasons the process has been longer in fructifying, and perhaps has met with more opposition. In the earlier forms the type of machine closely resembled that now used in whitewashing, against whose use many in the trade are loud in their complaints. In this process the lime or whitewash is pumped, under a pressure of about 35 lb., from a tank through a flexible tube carrying a nozzle, the aperture of which can be regulated to any degree of fineness by means of a trigger control. It is claimed for such means that an area of from 10 to 20 sq. yards can be covered per minute, with the additional advantage that in covering a rough, irregular surface, such as a brick wall, the lime or distemper is forced by the spray into the narrow interstices that cannot be reached by a brush. The opponents declare that the method is suitable only for the roughest jobs, that it can discharge but a thin, watery mixture, and that it is not possible to put tallow or any such ingredient into the lime. The author, in a chapter devoted to whitewashing, states that the process is growing in popularity. This is not impossible, for longer practice will give the familiarity necessary to obtain a good result, and greater experience will tend to correct any defects in the apparatus. As already hinted, the workman is apt to forget that the dexterity he has acquired with the brush has come from long usage, and that with the spraying-machines he is still an apprentice.

Paint, however, being of a more viscous character than whitewash or distemper, requires, in order to get a satisfactory result, a treatment that will ensure a very fine subdivision as it issues from the nozzle. A moderate degree of success followed from using air subject to a pressure of about 40 lb. per sq. in., driven through a nozzle controlled by a convenient trigger type of valve, so arranged that the air could impinge at an angle across a similar nozzle communicating with the paint receptacle of the sprayer. This gave rise to a fan-shaped spray, useful for many purposes, but was not suitable for coating small articles, or with heavy paints containing a fair percentage of varnish. A concentric form of spray now holds the field, and the author describes apparently every modification that has come on the market, supplying also not a little information concerning the many accessories that add materially to the usefulness or convenience of the apparatus. The spray, under proper control, is capable of many applications where the uninitiated would not suspect its presence, as, for example, in the speckled edges of bound books, or in the gold finish of a picture-frame. With a nozzle giving with ease and readiness the equivalent in brushes ranging from $\frac{1}{4}$ in. to 4 in., the spray is equally effective in painting a ship's hull or the smallest button.

Mr. Jennings follows the process of spraying in its many decorative and so-called artistic applications. With pride and confidence, he asks us to admire the effects of Japan finishes and steel enamels, grows enthusiastic over the many uses of varnish, and shows what an easy thing it is to coat wooden designs with metal, melted in the flame of an oxy-hydrogen blow-pipe, and atomised under high pressure. Stencils, when handled with dexterity, present no difficulties, and his excellent illustrations inform us of the charming effects that can be produced on such varied materials as lamp-shades and Christmas cards, pottery, and wall-paper. The interest is engrossing and infectious; we are afraid, however, that these illustrations display rather the skill of the artisan than the merits of the spraying-machine; and if the amateur is tempted to emulate these fancy flights, many a disappointment awaits him. The true field of utility for this form of depositing paint seems rather to lie in covering broad areas rapidly and uniformly than in attempting minute delicate tracery. Of the economy of time over brush-work, whether in dipping or spraying, there cannot be any doubt, and possibly there is some saving in material, for in dipping and in spraying over large surfaces there is no wastage through evaporation from open pots, from the gradual drying up of paint on their sides, or absorption in the brushes employed. In spraying small, slender articles, some paint is, no doubt, scattered and lost. In painting, however, labour is more costly than material, and the opportunities for diminishing expenditure are many and great. A case is quoted in which by substituting spraying for brush-work, one large shop was able to reduce the number of employees from 200 to 90. So far as this information goes it points to the possibility of turning out more work from smaller premises, and therefore less capital need to be sunk in building. Supervision is easier and the technique of mixing, drying, baking, &c., is likely to be improved. There does not appear to be any difference in the durability of the paint applied by either method, but possibly trials are not yet exhaustive. In adhering to the economic importance of the innovation the author is on safe ground, but to insist on the artistic merits seems a little out of place. Mere imitation of models, however choice, can never rise to real artistic merit, and the extensive use of elaborate stencils, necessary in some classes of work for the purposes of accurate reproduction, constitutes a mechanical process that can easily prove burdensome.

BOOKS RECEIVED.

Air-Screws: An Introduction to the Aerofoil Theory of Screw Propulsion. By M. A. S. RIACH. London: Crosby Lockwood and Son. [Price .]

An Introductory Course of Continuous-Current Engineering. By ALFRED HAY, D.Sc., M.I.E.E. Second Edition, revised. London: Constable and Co., Limited. [Price 6s. 6d net.]

The Geology of the South Wales Coalfield. Part XII. *The Country around Milford.* By T. C. CANTRILL, E. E. L. DIXON, H. H. THOMAS, and O. T. JONES. London: E. Stanford, Limited, and T. Fisher Unwin, Limited. [Price 2s. 6d.]

The Thicknesses of Strata in the Counties of England and Wales, exclusive of Rocks older than the Permian. By A. STRAHAN, T. V. HOLMES, H. DEWEY, C. H. CUNNINGTON, W. C. SIMMONS, W. B. R. KING, and D. A. WRAY. London: E. Stanford, Limited, and T. Fisher Unwin, Limited. [Price 4s. 6d.]

The United States Bureau of Mines: Technical Papers. No. 83: *The Buying and Selling of Ores and Metallurgical Products.* By CHARLES H. FULTON. No. 108: *Shot-Firing in Mines by Electricity controlled from outside.* By H. H. CLARK, N. V. BRETH, and C. M. MEANS. No. 109: *Composition of the Natural Gas used in Twenty-five Cities.* By G. A. BURRELL and G. G. OBERFELL. No. 110: *Monazite, Thorium, and Mesothorium.* By KARL L. KITHIL. No. 114: *Heat Transmission through Boiler Tubes.* By HENRY KREISINGER and J. F. BARKLEY. Washington: Government Printing Office.

Excess Profits and Excess Mineral Rights Duty. By W. E. SNELLING. London: Sir Isaac Pitman and Sons, Limited. [Price 7s. 6d. net.]

The Annual Report of the United States Coast-Guard for the Fiscal Year ended June 30, 1915. Washington: Government Printing Office.

PERSONAL.—The Skefko Ball-Bearing Company, Limited, Luton, sole manufacturers in this country of "Skefko" (S.K.F.) Double-Row Self-Aligning Ball Bearings, have opened a new district office for Scotland at 45, Bothwell-street, Glasgow.—Messrs. Heathman, of Parson's Green, Fulham, have opened extensive showrooms for their ladders, portable telescopic scaffolds, &c., at 35, Aldersgate-street E.C., near the General Post Office.

DRAUGHTSMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to the letter by your correspondent "Staffed," all I can say is: Thank heaven he is not representative of draughtsmen as a class. If he is so incapable of holding his own, let him by all means join one of the trade unions he appears to think so highly of. I might suggest that his salary was reduced (I admit, by a rather unscrupulous employer) in order to conform more nearly to the value of his services, and also possibly as a gentle—if unpleasant—hint that his services could be dispensed with.

The fact that he remained at his situation, and the attitude he has taken up towards his firm, which obviously prevents him doing his duty fairly (and which agrees perfectly with the attitude among a great number of engineering workmen which has been responsible for the shortage and holding back of munitions), gives colour to this view.

For my part I have found employers straightforward if approached, not in a servile manner, but in a way that shows they are dealing with a self-reliant and self-confident person; two attributes "Staffed" evidently does not possess.

I also take exception to the statement that trade unionists "have doubled, &c.," their wages solely by the assistance of the unions. The facts are that skilled men previous to the war were, in the majority of cases, receiving very little extra in comparison with the wages *received* by the "munition makers" who have been drawn from the unskilled class. This assertion of your correspondent is a very popular belief, which should be corrected at the earliest opportunity.

Finally, I would say that "Staffed" is evidently in the frame of mind to cause him to attempt to "do" his employer, who is probably sharp enough to see it, and when, as a reward for his industry, his services are dispensed with, he will probably grumble at his "bad luck"(?), rail still more loudly at employers as a whole, and wait while a trade union sees fit to "double, &c.," his wages.

Yours, &c.,
H. S. ELLSON.

68, York-street, Rugby, July 2, 1916.

OIL-ENGINE NOMENCLATURE AND THE DIESEL ENGINE.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has just been drawn to an interesting letter in your issue of June 23, by Mr. Herbert Akroyd Stuart, relating to oil engines, in which he points out that he patented the method of compressing air *only*, and the injection of liquid fuel thereinto, in 1890. It is rather curious that in 1891 I described in patent 816 a heat engine which compressed air *only* into which powdered solid fuel, or liquid fuel, was afterwards injected by a timed jet of superior pressure air. A distinct claim was made for this *modus operandi*, which is similar to that of present-day commercial Diesel engines. In Mr. Stewart's engine and my own hot surfaces were essential features of the combustion chambers, so there was no need for the extremely high compression pressures adopted by Herr Diesel when he followed us with his 1892 patent. This very high pressure, which gave an air temperature sufficient to ignite the fuel when introduced, was the real novelty of his specification. Ignition of combustible matter by air compression is, of course, ancient. It has long been a favourite experiment at science lectures, and certain savage tribes have for centuries obtained fire by ignition of touchwood in air compressed by dropping a close-fitting stone piston into a long wooden cylinder. Nevertheless, to Mr. Diesel belongs the honour of first applying this mode of ignition to internal-combustion power engines. Therefore I do not agree wholly with the late Mr. Charles Brown, the celebrated engineer of Basle, who, in 1901, reported to the General Electric Company, of New York, as follows, through an agent of that concern: "No drawings have yet been published of Maccallum's engine, but he (Mr. Brown) has got copies of Maccallum's patents, and it seems to him that the principle is identical with the Diesel. Diesel's first patent is dated 1892, and Maccallum's 1891, so that Maccallum anticipates Diesel."

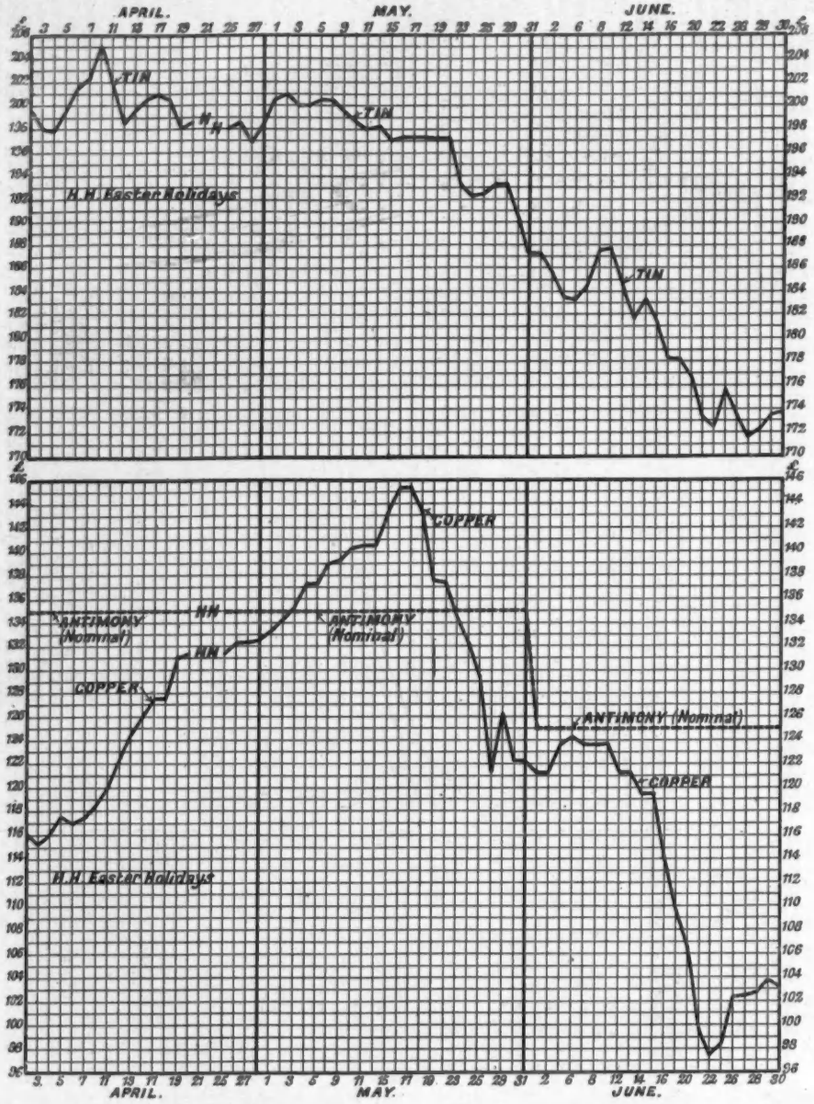
These matters, however, are now of only historic interest, and it is more useful to remember the very generous financial support afforded to Mr. Diesel by his compatriots, and notably by Heinrich Buz and Fried. A. Krupp, without which the engine could never have become a commercial success. In 1912, when addressing the German Shipbuilding Society, the inventor stated that his experimental work up to 1897 in the production of a successful 20-horse-power oil motor had cost 22,500*l*. Mr. Stuart, in his letter, says that he expended 16,000*l*. in perfecting two small oil engines. In my own case I think I may fairly claim to have achieved a considerable measure of success in the much more difficult task of producing a true coal-burning internal-combustion engine of about 40 horse-power on an expenditure of less than 3,400*l*.; before the work had to be abandoned for want of further funds in 1902.

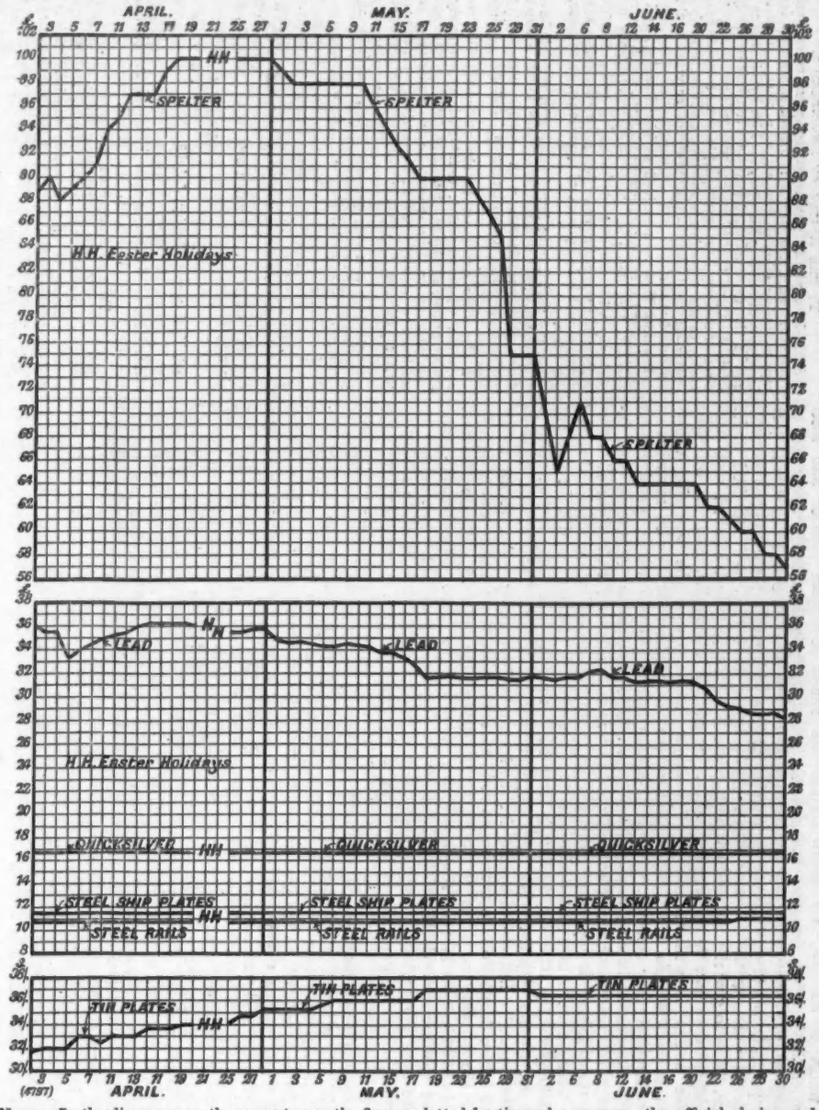
I am, Sir, yours truly,
P. F. MACCALLUM.

93, Hope-street, Glasgow, June 30, 1916.

FRENCH METAL AND TIMBER COMMITTEE.—By virtue of a decree dated June 11, 1916, a committee has been appointed at the French Ministry of War to centralise the acquisition of metal and timber from abroad and to distribute the material imported, together with that of French production, to the best interests of national defence. The members of the committee are taken from the various Ministries and from various military and naval corps.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.*





* On March 1 last an Order made under the Defence of the Realm Act prohibiting speculative dealings in copper, antimony, spelter, lead, iron, and other metals required for war work, was published in the *London Gazette*. In consequence of this Order business in these metals was suspended on the London Metal Exchange, and also on the Glasgow Pig-Iron Warrant Market, on the following day. The Order, however, was not intended to restrict legitimate trading, and business of this kind was therefore resumed in London on March 6 and in Glasgow on March 7. At the close of the Glasgow Iron Market on the 31st May a notice was posted up stating that "owing to the action of the Minister of Munitions, the Glasgow Pig-Iron Warrant Market is suspended till further notice." Since that date quotations have been nominal at the prices which then prevailed—viz.: Hematite 6*l.* 2s. 6d.; Scotch, 4*l.* 8s. 6d.; and Cleveland, 4*l.* 2s. 6d. per ton.

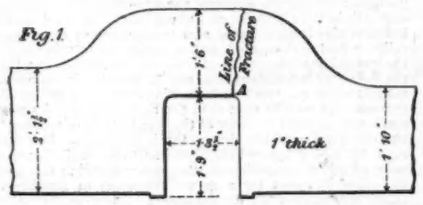
Note.—In the diagrams, on the present page the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal respectively. The prices plotted for antimony and lead are for English metal in both cases, while those for spelter are for American metal—the only kind at present available. Steel ship-plates and heavy steel rails are plotted to Middlesbrough quotations; the usual discounts are allowed in the case of ship-plates, but rails are net, free on board, at Middlesbrough. The figures plotted for hematite, Scotch, and Cleveland irons are Glasgow settlement prices, and these prices are per ton, as are also those for all other metals previously mentioned. The price of quicksilver is, however, per bottle, the contents of which weigh about 80 lb., and the price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market day, and the horizontal lines represent 1*l.* each in all cases, except those of hematite, Scotch and Cleveland irons and tin-plates, where they represent 1s. each.

REPAIRING FRACTURED LOCOMOTIVE ENGINE FRAMES BY OXY-ACETYLENE WELDING.

In rebuilding locomotive engines, these are in many instances fitted with a much heavier boiler than when turned out new, the object being to augment the tractive power or hauling capacity by means of a larger production of steam at an increased pressure. As the engine frame-plates are seldom altered or strengthened to meet this increased weight of the new boiler, failures through fractured frames are quite a common occurrence on some railways. As a consequence, the engines are laid up for many weeks under repairs, as, if the ordinary method of welding is adopted, the work to be done involves dismantling of the engine to remove the broken frame-plate to the forge.

Frame-plates are also greatly strained in running-sheds when being lifted from the front end only by means of a crane fitted to shearlegs or engine hoist for the repairs to axle-boxes and axle-box guides; and as the horn-clips must be taken off to get these parts removed, a considerable tensile strain is set up in the weakest part of the frame—that is to say, at the small corners above the axle-box guides. As shown at A on the accompanying sketch, incipient fractures are here developed, resulting finally in broken frames.

To overcome these difficulties, the system of welding broken frames by means of the oxy-acetylene process is being largely adopted by many of the principal railways in their engine-repairing works. The advantages of employing the oxy-acetylene process consist mainly in the work being accomplished without dismantling the



engine further than the removal of the wheels and axle-box guides for access to the part to be welded, while the work is generally executed at about one-tenth the cost of the ordinary method of welding on the forge.

The plant required comprises an acetylene generator of adequate proportions, together with a gas-holder of ample size for the gas consumption, and a specially-designed blow-pipe for using dissolved acetylene and oxygen.

The gas is conveyed in wrought-iron pipes permanently fitted up, above ground, in the workshops, and provided with suitable connections or unions for the flexible piping attached to the blow-pipe, at places selected in the erecting-shop for repairing engines arriving with broken frame-plates.

The sketch herewith shows a very common case of an engine frame-plate broken above the driving axle-box, and the following particulars are given of the actual cost of completing a weld 18 in. long on a plate 1 in. thick :—

	£	s.	d.
440 cub. ft. of acetylene at 2d. per cub. ft.	3	13	4
490 cub. ft. of oxygen at 50s. per 1000 cub. ft.	1	4	6
7 lb. of iron wire at 3d. per pound... ...	0	1	9
Two welders, nine hours, at 5s. per day ...	0	10	0
Two labourers, nine hours, at 3s. per day...	0	6	0
Total	5	15	7

This works out at the rate of 6s. 5d. per inch welded, a thorough sound job being made, and the engine turned out to traffic within two days for repairs.

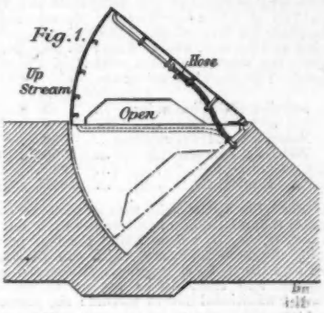
Had this job been done by the ordinary method referred to above, the time occupied for dismantling and re-erecting would have been fully two weeks and the cost at least 50*l*. In railway works, where as many as forty engines may have to be dealt with in a year, the saving effected of labour and time is a most substantial one.

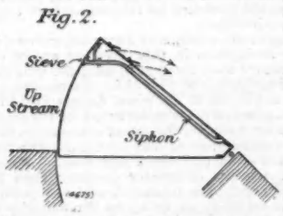
When the plant is not required for engine repairs it can be turned to good account in other work, such as piecing tubes—that is, putting new ends on old tubes, making them almost equal to new ones. It can also be used for repairing burst water-pipes in winter time, or tank-plates damaged by corrosion, welding cracks in motor work, &c. It can also be turned to account for cutting up old boilers for scrap and also for cutting the outline of new engine and tender frame-plates, instead of using a powerful punching-machine.

MOVABLE SECTOR WEIR NEAR BREMEN.

The big dam and sector weir which crosses the Weser River near Bremen marks an interesting development of the American type of bear-trap weirs. It is also, or was when being built, the first of its kind in Europe, and it surpasses in dimensions by far the movable dam of the Chicago Drainage Canal near Lockport, which the Bremen installation resembles. In both cases the plant comprises a dam and weirs, a fishway, a series of turbine-chambers for the utilisation of the water power, and a lock. At Lockport there are two movable crest weirs, one 48 ft., the other 12 ft. in length, facing one another; at Bremen the two weirs, each 54 m. (177 ft.) in length, are both along the main axis of the dam which crosses the river from north to south. At the spot, 5 km. above Bremen, the Weser flows towards the west, but describes a curve to the north; the ships have to enter the lock, 350 m. (1150 ft.) in length, on that curve, which is not a desirable feature.

The Bremen dam was required because the regularisation of the river and the contemplated creation of a navigable channel from Bremerhaven up to Bremen for vessels of 7 m. (23 ft.) draught had lowered, and threatened further to lower, the water level in the upper reach of the river and depreciated the agricultural value of the adjacent land. On an average, the dam is to hold up the water about 12 ft. in height; in winter the height rises to 5.5 m. (18 ft.), and the tidal range at the dam





varies between 1.5 m. and 2.7 m. (about 6 ft. to 9 ft.). Each weir forms a hollow horizontal sector of a cylinder of 6.5 m. (21½ ft.) radius, which turns about its horizontal axis or shaft (54 m. in length, as mentioned) when rising from, or descending into, its pit, of the same shape, the angle of the sector being about 45 deg. The weight of each sector is 129 tons, 2.4 tons per metre. The cylindrical surface faces the head-water, the shaft lying on the down-stream side (see end elevation, Fig. 1. Sector weirs operate like bear-trap weirs. A conduit extends from the sector pit, which is otherwise fairly water-tight, into the head-water. The pressure due to the head of the water passes through this conduit into the pit, and balances the weight of the structure and of any water over it. The dam, being thus in equilibrium, may be raised or lowered by raising or lowering the water level in the pit. This is effected by means of a tubular valve, called the weir tube. From the conduit above mentioned, a branch extends vertically upward; in the upper part of this tube, 1 m. in diameter, there glides up and down, in telescope fashion, the weir tube proper, the upper rim of which forms an adjustable weir or overflow, discharging into a special conduit. The height of this weir fixes the possible pressure in the sector pit. The weir tube is suspended from the shaft of an electric motor, and is thus raised or lowered. As, however, the weight of the moving weir varies with the height of water on the top of the weir. Mr. Plate, one of the engineers in charge, has suspended the weir tube from two pulleys; the one pulley is turned by the motor, the other by the moving weir itself, and two electrical contacts, the one above the other, are provided for the motor and the vertical motion of the weir tube.

Some other interesting novelties, partly due to Mr. Plate, have been introduced at the Bremen dam. As the weir will not rise when its top lies horizontally, flush with the pier surface, a flexible air-hose has been attached to the under side of the weir sector (Fig. 1); this hose moves with the weir, and ends inside near the crest in a recess, specially closed at the sides and top. Air under a head of water of 50 cm. (20 in.) is sufficient to start the weir and to raise it about 40 cm. out of the horizontal; it will afterwards follow the weir-tube adjustment. Another trouble may, however, arise from any air caught in the structure when the weir is to be lowered. To remove this air, three siphons have been fixed in each weir (Fig. 2); the siphons lie within the weir body just below the inclined top, and they terminate above, in the cylindrical surface, 0.90 m. (3 ft.) below the crest, and at the other end, on the top, close to the shaft; near the upper outlet a smaller tube has been carried from the siphon up into the crest. The water rushing through the siphon sucks the air out of the upper portion of the weir body, so that the weir sinks quickly. A further difficulty creeps in, however, when the water rushes over the weir crest. Eddies and a partial vacuum are then set up near the crest, and another kind of suction effect tended to keep the weir at an angle of about 12 deg. to the horizontal. In order to overcome this difficulty, eight flap-valves (Fig. 2) were so arranged in the top of each weir, near the crest, that the water in the weir body can rush out, but that water cannot enter into the weir body from outside; these valves are adjustable. The changes in the water and air pressures in the weir body are observed by the aid of lead tubes which are carried from the weirs to the office of the engineer in charge of the dam.

The Lockport dam to which we have referred was completed in 1908, the movable crest-weirs having been built by Mr. E. L. Coolidge. The construction of the Bremen dam and weirs were commenced in 1909; the dam was opened in 1911; the embankments were overhauled in the following year, and some of the novel devices to which we have alluded were then added. A description of the whole installation was only published this year in the *Zeitschrift des Vereines Deutscher Ingenieure* of January 29 and February 5, 1916, by the engineer superintending the operation, Mr. Kölle; Mr. Plate reserves a detailed description of his improvements. The shaft, 100 mm. (4 in.) in diameter, rests in bearings of cast iron lined with white-metal, and is built up of sections, 2.6 m. (8½ ft.) in length. The length of each weir being 177 ft., there was first some danger of tilting; the one end of the shaft was sometimes nearly 20 in. higher than the other, and the special caps fixed to the bearings, so as to make them embrace more than 180 deg. of the shaft circumference, were wrenched off; the bolted-on plates then adopted answered very well. One of the chief minor difficulties has been to prevent sand from finding its way into the pit; leather packing, stiffened by galvanised iron, has given satisfaction in this respect. On the whole, the selection of a sector weir has justified itself. The river is tidal, and may carry drifting ice for weeks. That the shaft and part of the mechanism are under water is a drawback. On the other hand, the construction and mechanism are very simple and not expensive, very little attendance is required, and the wear and tear have been very slight. The weirs can be fully raised and lowered within 10 minutes.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on some colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

South Africa.—The Office of H.M. Trade Commissioner in South Africa reports that the *Cape Provincial Gazette* contains a notification to the effect that the Molteno Municipality (Cape Province) proposes to borrow 20,550*l*. for the execution of a water supply scheme.

Portugal.—With reference to Bills (1) to authorise the Municipality of Amarante to contract a loan of up to 120,000 escudos for a hydro-electric installation, market construction, water supply and sewerage systems, and (2) to authorise the Municipality of Guimarães to raise a loan of 490,000 escudos for the installation of an electric tramway system, the construction of a workmen's quarter, the laying out of a park, the erection of a new municipal building, and water supply systems, it is notified that the *Diario do Governo*, Lisbon, publishes the text of Laws based on the Bills referred to and sanctioning the raising of the loans required for the purposes mentioned. (Escudo=about 2*s.* 11*d.* at current rate of exchange.)

The Gateway of India.—What is known as the Gateway of India scheme is a proposal to undertake a small reclamation on the south side of the old Bandar at Bombay and to extend into the harbour a projecting mole, on which the gateway will be erected, with the necessary flights of steps and tidal landings. The total area which is being reclaimed, including the mole, is approximately 7,700 sq. yards, of which 1,800 sq. yards are occupied by a pavilion, steps, and sloping way, giving an additional open space for the public, exclusive of the present area, of 5,900 sq. yards. The advantages of the scheme are that, being extended farther into the harbour, the landing stage will be greatly improved, as sufficiently deep water will be available for launches at any state of the tide, while the increase of open space will be a great boon to Bombay citizens who take the air in the evenings on the Bandar.

CONTINUOUS-CURRENT RAILWAY MOTORS.*

By ERNEST V. PANNELL, Associate Member.

Introductory.—It should be explained at the outset that the title of this paper is intended to cover some interesting features in the design of continuous-current motors for railway motor-car operation. The design of locomotive and alternating-current motors, whilst offering much that is of interest, is too wide a subject to be dealt with here. Few forms of electrical machinery have seen more rapid and efficient development than the traction-motor; in little more than 20 years it has grown from the open-type, double-reduction machines of Sprague, Short, and Vandepoele, rated at about 10 kw. to 15 kw., to the compact, ventilated, interpole 200-kw. motors in common use on our underground and suburban railways.

The year 1895 saw practically the end of the "trial-and-error" stage of electric railway engineering, and the establishment of a common basis of design for railway motors. This comprised four-pole structures of waterproof design, series excitation, drum armature-winding, usually of the two-circuit type, and a speed at rated load of about 500 revolutions per minute, thus permitting of single-reduction gearing. Developments of more recent date, however, offer much that is of interest to the designer and user of electrical machinery.

The study of the railway motor can best be approached by a brief survey of the requirements of such a machine. The widest field for electric traction in densely-populated countries like Great Britain and the eastern United States is for urban and suburban railway service in the industrial areas. Typical average conditions for such a service are the running of trains of 150 tons weight at a schedule speed of 16 miles per hour, with two stops per mile. Such a train would conceivably have five cars, the front and rear ones carrying motors and weighing 40 tons each fully loaded, whilst the remainder would be trailers. The service would call for an average initial acceleration of at least 1.5 miles per hour per second, necessitating an aggregate tractive effort at the wheel-treads of 23,000 lb. Now, as the weight per axle of the motor-cars is only 22,400 lb., the maximum tractive effort per axle with a friction coefficient of 0.2 would be 4480 lb. The most usual motor arrangement would consist in driving every one of the eight motor-car axles; each of the motors would therefore have to exert a tractive effort of about 3000 lb. If the train be accelerated up to 15 miles per hour on the rheostats, the output of each motor during acceleration would be 90 kw., and this figure would in all probability approximately represent the rated capacity of the machines on the one-hour basis. Alternatively, the weight of the motor cars might be so distributed as to throw a greater proportion upon the leading trucks, and two motors per car, each motor rated at 180 kw., be employed.

The foregoing are typical straightforward conditions of electric suburban service; in many circumstances, however, the requirements are of a much more onerous nature. Electric traction has to contend with heavy grades, short-radius curves, subaqueous tunnels, heavy rush-hour and excursion overloads, and often unskilled operation. Motor-cars are frequently kept in practically continuous operation for from 18 to 20 hours per day. The railway motor is therefore a piece of machinery liable to very severe usage, and its design and construction in accordance with its service conditions form an interesting study.

Throughout the paper the following assumptions apply:—

1. The rated output is the power delivered through the gears according to the standard 1-hour basis of rating (see appendix).

2. Power throughout the paper is defined in kilowatts, the horse-power unit for motor-rating being considered obsolete.

3. Voltage, except where otherwise specified, is assumed to be 600.

4. Rated speed or rated current is the speed or current corresponding to the rated output, as in 1.

5. The object of the paper being to consider general tendencies in design, the curves and tables should be regarded as representative of such tendencies rather than of precise quantities.

Weights and Dimensions.—In the last few years, owing partly to the competition of the alternating-current motor, but more to the widespread demand for increased economy in all branches of engineering work, considerable improvements have been effected in the design of the traction motor. Figs. 1 and 2 show one direction in which this improvement has been manifested. The dotted curves represent the average weight in pounds (including pinion, gear, and gear-case) of the railway motors in general use up to about the year 1909, whilst the full lines show the weights of motors, of similar output, designed since this date and in operation to-day. These latter, it is interesting to note, are almost all of the commutating-pole type.

In all parts of electrical railway equipment dead weight is an objectionable feature, and nowhere more so than in the motors where these are suspended directly upon the trucks. The nose form of suspension in general use throws about half the weight of the motor upon the axle without any intervening springs; owing to the thrust of the gears this proportion is increased or diminished during acceleration according to the position of the motors. Moreover, owing to the motor armature rotating from three to four times as fast as the wheels, the energy stored up in it during the accelerating periods will be very considerable, and for this reason minimum weight and armature speed are desirable. A typical calculation for the value of this momentum has been worked out by Mr. F. W. Carter.*

The following figures are of interest as showing the weights of two motors of identically the same rated output at 500 volts. The G E 74 machine was, however, introduced in 1904 and the G E 201 in 1910.

	G E 74	G E 201
Type of motor		
Rated kilowatts	48	48
Weight; motor without gears	3110 lb.	2385 lb.
Weight; armature and pinion	845 „	639 „
Weight; gears	240 „	220 „
„ gear-case	175 „	130 „
„ motor and gears, complete	3534 „	2735 „
per kilowatt, rated output?...	74	57

This reduction of nearly 800 lb. in weight has been secured partly by the increase of rated speed made possible by the adoption of commutating poles, but to a greater extent by the use of more carefully-chosen material of higher weight efficiency and a ventilated structure. The rated output given above does not by any means represent the service capacity of the two motors, since, owing to its ventilated design, the G E 201 motor will have a sustained capacity not less than 50 per cent. in excess of that of the older type of machine.

A closer investigation of the curves in Fig. 1 will show the desirability, from the weight-efficiency point of view, of employing a few motors of high capacity rather than a greater number of low capacity. Let us consider alternative arrangements for the equipment of a train of six cars, two of which are motors. Service requirements necessitate the expenditure of 720 kw. at the wheel-treads during acceleration, and this may be accepted as representing the aggregate rated output of the motors employed. The two alternatives are:—

	I.	II.
Number of driving axles ...	8	4
„ motors	8	4
Rated kilowatts per motor ...	90	180
Weight per motor	4000 lb.	6200 lb.
Cost per motor	230*l.*	340*l.*
„ total	1840*l.*	1360*l.*

It need hardly be said that conditions occasionally dictate the adoption of Alternative I., but *cæteribus paribus*, it may be affirmed that the best practice is to employ the largest motors which can be economically loaded on the lightest service. Rheostats, contactors, reversers, and train cables require to be duplicated for every additional pair of motors; the above disparity in costs would therefore be far greater were the complete equipment included.

Turning to the question of linear dimensions, it is found that the limitations in this direction are of even more strict a nature than those governing the weight. On the standard rail gauge of 4 ft. 8½ in. the maximum distance between the inside of the wheel flanges is 52 in., which, of course, positively limits the length of the motor-casing. In the other direction the wheel diameter is the limiting feature, and in view of the minimum structure gauge, height of station platforms, and head clearance within the cars, a wheel of greater diameter than 36 in. has seldom hitherto been tolerated, and as a matter of fact the size in common use on by far the majority of electric suburban, elevated and subway railways is 33 in. However, it is interesting to note a recent more liberal tendency in this direction, and there is no doubt that wheels of 36 in. to 42 in. will become standard except where tunnel limitations are too severe. With the 33-in. wheel the radial distance corresponding to the armature radius, air-gap, length of pole-piece, and thickness of motor shell, is obviously something less than 16½ in., which gives a minimum armature diameter of 20 in. The axial length of the armature core is still further restricted owing to the fact that with increasing output more lateral space is demanded for the gears and commutator; this leaves about 15 in. as the maximum practical length of core between end plates for a 600-volt motor of about 200 kw. rated capacity.

In most classes of electrical machine a fairly close relation can be established between the size of armature and the output, and in Fig. 3 an attempt has been made to represent the law as applied to traction motors on the one-hour rating. Curve A represents a series of interpole designs worked out by the author, whilst the points indicated refer to machines in actual service from which the constants have been derived. As will be seen, British, American and Continental designs are included, and the agreement is fairly close. The step at the end of the curves relates to motors with duplex gears, this being an expedient adopted with machines of very heavy output at a fairly low speed. The torque being too great to be satisfactorily transmitted though one pinion, gears are mounted at either end of the motor-shaft; this necessarily narrows down the axial length of frame and armature core, therefore calling for a greater armature diameter.

Motors of this size and type are of interest, however, only for locomotive work and are therefore outside the scope of this paper. It is interesting to compare the curve relating to railway motors with that plotted for stationary machines; the great disparity is, of course, due mainly to the system of rating employed.

Speed and Tractive Effort.—Railway motors, being invariably series wound, attain high rotational speeds at light loads. The free-running speed in service usually coincides with about one-third the rated load, and is nearly double the rated speed. In other words, a motor having an armature diameter of 20 in. and a rated load speed of 600 revolutions per minute would attain a rotational speed of about 1000 revolutions per minute and a peripheral speed of 5250 ft. per minute when free running. With higher degrees of saturation the increase of light load will not be as great, but in any event it will be very near the maximum judicious peripheral velocity. This, together with the fact that the gear and friction losses are greatly increased at high rotational speeds, provides an argument against the use of higher rated speeds than 600 revolutions per minute. Indeed, this figure may be said to cover practically all types of motor for car operation other than those designed for control by sectional fields. Consideration of the proportionment of losses in the machine may, as will be seen, sometimes dictate the use of a somewhat lower or higher speed of certain types of service, but 600 revolutions per minute is a good average value for satisfactory designs. The main disadvantages of extreme speeds may be indicated as follow:—

High Speed.	*Low Speed.*
High core and friction losses.	High copper losses.
	Excessive pinion stresses.
Excessive forces on armature.	Poor ventilation.
Faulty commutation	Heavy machine.

In general the efficiency of the high-speed motor is better at rated load and inferior at light loads as compared with the lower-speed design. In the former motor the core and friction losses are higher, and the copper losses, owing to the fewer armature turns, are less; this in a measure discounts the high-speed motor for service involving much high-speed running. On the other hand, the lower-speed motor having a higher armature resistance will be less desirable for work involving frequent accelerating periods at the full rated current; it will operate with higher efficiency on long straightaway runs with few stops.

The influence of the form of saturation curve upon the motor characteristics has been well illustrated by comparison with curves showing the hypothetical maximum and minimum degrees of saturation.* Figs. 4 and 5 indicate the typical speed and torque curves for a large railway motor compared with similar characteristics of a theoretical machine with maximum saturation in which the field flux is constant, and also of a motor in which the saturation is nil, the flux increasing as the square of the current. It will be seen that the actual practical design tends towards one or other of these extremes, according to the service for which the motor is designed. For long runs without stops, where time has to be maintained in spite of adverse conditions, the motor showing the least variation in speed for a given difference in torque—in other words, the highly saturated motor—is desirable. On the other hand, for services with frequent stops, involving rapid acceleration, a fair proportion of the running will be upon the motor speed curve, which needs therefore to be of the flexible type, characteristic of a machine with a less highly saturated magnetic circuit. The saturation curves of four motors in very extended use comprising two different makes are shown in Fig. 6.

It should be noted that the motor losses will influence the characteristics, copper losses tending to reduce the speed, and core losses to diminish the torque.

Commutating Poles.—From the nature of its design the continuous-current traction-motor must be expected to commutate poorly compared with stationary machines of similar output and voltage. In generator design it is usual with increasing output to increase the number of poles and of parallel paths through the armature in order to improve the collection of current. These devices are, of course, inapplicable in the case of traction-motors, on account of the confined space; the armature size is limited and the number of poles is restricted to four. Moreover, in order to balance out inequalities in the air-gap and to permit of operation with only two brush sets, the two-circuit winding is universal. Practically all motors of 100 kw. and over are designed for one armature turn per segment in order to reduce the reactance per coil, but until the general introduction of commutating poles no other device could be adopted excepting the maintenance of a well-saturated magnetic circuit, a wide neutral zone, and the lowest practicable commutator speed. Even with motors of the most careful design and construction the reactance voltage at rated load is of the order of 9 or 10, or four times that of a reasonably good generator. Certain motors have been designed with four brush sets, mainly with the idea of shortening the commutator and providing more space for the armature core. It has been found difficult, however, to secure adequate space for the four brush studs and still to maintain sufficient spacing to guard against flash-overs; moreover, the increased friction and heating offset the improvement (if any) in the commutation.

A device which has found universal adoption is the grooving out of the commutator mica to a depth of about $\frac{1}{32}$ in. below the surface of the copper. This avoids any trouble due to high mica, and has a remarkable effect in keeping the commutator surface clean and cool. Soft brushes are, of course, never employed with this type of machine, and with the hard carbons in common use centrifugal force is found quite sufficient to keep the slots free from particles.

In the early days of electric railways certain Sprague motors were designed with compensating windings to neutralise the armature flux; but the commutating-pole proper was not commercially applied to traction motors until the year 1905. At this time interpole motors rated at 100 kw. were put into operation on the 1000-volt continuous current railway running from Cologne to Bonn. Two years later a similar type of motor was placed upon the market in the United States, although it was not until

* Paper read before the Institution of Electrical Engineers.

* Journal of the Institution of Electrical Engineers, vol. 1, page 437, 1913.

* Parshall and Hobart: "Electric Railway Engineering," page 58.

the year 1908 that any of these American-built machines were advertised as being applicable to pressures much in excess of the standard 600 volts. Now, however, commutating-pole motors are being regularly supplied with 2400-volt insulation and 1200-volt commutators for running two in series on a 2400-volt line. The broad advantage obtained by the use of interpoles is the greatly reduced chance of flash-overs. The reactance voltage being practically neutralised and the sparking proportionally lessened in severity, there remains little to start an arc from brush to brush or to frame. The commutating-pole machine therefore becomes a stronger type of motor, capable of heavier short-time overloads and higher speed and voltage, whilst its maintenance charges are greatly reduced.

An important influence of the commutating-pole upon the design of the motor is the increase of the armature and decrease of the field component in the same proportion. To accommodate the interpole the neutral zone has to be slightly widened and the polar arc shortened; consequently the total flux entering the armature from the main pole is reduced to a corresponding degree. On the other hand, the reduced armature reaction permits of an increased loading in ampere-turns on the armature. Moreover, although it has been urged by some designers that the commutating-pole could never be introduced into railway motors on account of the confined space, it is found that the traction motor is no larger, and, as already seen, is lighter than the pre-interpole machine. A notable instance of the use of the commutating-pole in a motor of extremely limited size is found in the machines on the Moselhütte mineral line in Lorraine, where the locomotives are operated at 2000 volts, the pressure on each motor being 1000 volts. The gauge of the line is only 39½ in., notwithstanding which it has been found possible to equip the locomotives with motors rated at 120 kw., the armatures being of 26 in. in diameter, with a core length of only 6½ in.

Table I. gives the outline design features of typical modern commutating-pole railway motors for 600-volt operation.

Field-Control Motors.—As already seen, although 600 revolutions per minute represents the average speed at rated load of by far the majority of satisfactory designs, there are occasions where some variation of this quantity is desirable. It is frequently the case that a certain type of motor being standardised by a railway company will be called upon to perform widely different classes of service, possibly interchanging local service, with as many as two stops per mile, with express schedules running five miles or more without a stop. For the local service, high-speed, low-copper-loss motors are required, having a low-speed gear, whilst the most suitable machines for the fast service are those rated at a lower speed and having a low core loss and high-speed gearing. The use of sectional or tapped field control affords one method of effecting the compromise and operating a system of diverse characteristics with one type of motor. More valuable still is the use of field control for notching up on the controller during acceleration. A motor designed for this principle will probably have at its full field a speed 10 per cent. lower than the average machine, whilst with the short field this speed is increased by some 25 per cent. The motor is thus able to run upon either of two speed curves at the will of the motor-man.

Sectional field control was used on some of the very early motors, but the method later fell into disuse, and it was not until the general adoption of the commutating pole that field control was definitely established. Without interpoles, as may be imagined, field weakening leads to excessive rushes of armature current, sparking, and flashing over. To a small extent these troubles in earlier motors of the type were due to the shunting of a portion of the field winding rather than to its being open circuited. Such a procedure naturally increased the lag of the field current, opposing the growth of the flux, and serious sparking was the result. The commutating characteristics are so improved in the interpole machine, however, that reduction of the main field by 50 per cent. does not appear to affect the collection of current. Typical speed curves for a field-control motor are shown in Fig. 7, page 26.

Fig. 1.
WEIGHTS OF CONTINUOUS-CURRENT RAILWAY MOTORS AT 600 R.P.M. RATED SPEED.
Broken Curve, Designed before 1908.
Full Curve, Present day Designs.

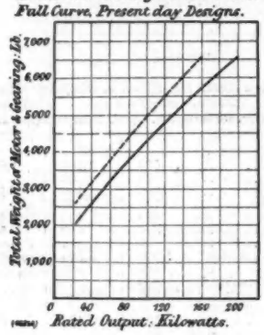


Fig. 2.
UNIT WEIGHTS OF RAILWAY MOTORS CORRESPONDING TO FIG. 1.

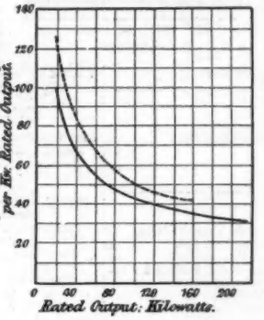


Fig. 3. *RELATION OF OUTPUT TO DIMENSIONS OF ARMATURE.*
Curve A. Geared Railway Motors, 600 R.P.M.
„ B. Hobart's curve for C.C. Machines. 600 R.P.M.
** Indicates British, ▲ American, and ▲ Continental designs.*

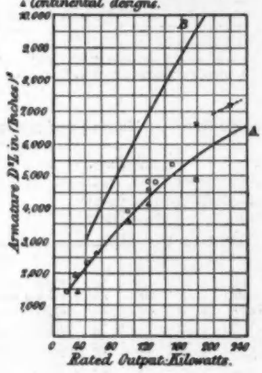


Fig. 4. *SPEED CURVES.*
(A) Limiting Min.m Saturation.
(B) „ Max.m „ „
(C) Typical 170 Kw. Railway Motor.

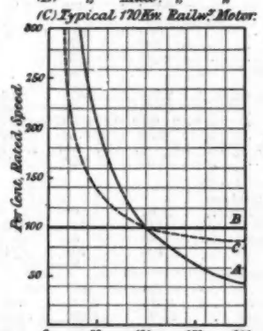


Fig. 5. *TORQUE CURVES.*
(A) Limiting Min.m Saturation
(B) „ Max.m „ „
(C) Typical 170 Kw. Railway Motor.

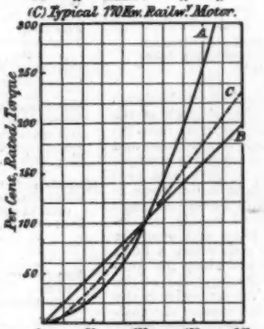
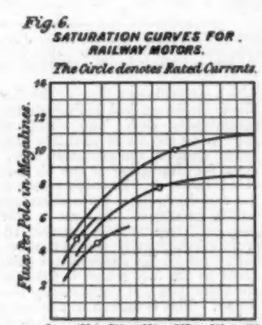


Fig. 6.
SATURATION CURVES FOR RAILWAY MOTORS.
The Circle denotes Rated Currents.



The "full-field" characteristic of a motor of this type should be a good flat curve, denoting extremely high saturation; otherwise the "short-field" curve will show dangerously high speeds at light loads; 450 revolutions per minute for the rated load speed at full field, and 550 or 600 at short field are typical of what has been found most satisfactory practice for a 200-kw. motor. Too great a disparity in the speeds at any given armature current leads to a pronounced current "kick" when changing, and would probably tend to induce flashing over.

To those accustomed to laying out performance curves for electric railway equipment it is sufficient to say that the field-control motor provides a shorter rheostatic period and a much longer period of motor speed-curve running. The lower the full-field speed of the motor the quicker will the rheostats be cut out, and the less the rheostatic losses for a given acceleration rate. On one of the suburban railways in Christiania, Norway, the field windings of the 1200-volt motors are not only divided for short and full fields, but are grouped for series and parallel connections. This gives four different running speeds, all with the motors directly on the line. By this means nearly half of the controller notching may be performed free of rheostats, and a good approximation to alternating-current tapped-transformer control is effected. The mere tapping off from a single point near the middle of the field winding is becoming standard practice, however, in view of the simplicity of the necessary controller connections.

Rating.—Under this heading are discussed the associated subjects of efficiency, losses, and heating. The output of a railway motor is based upon a certain definite temperature rise under certain definite conditions, which is closely related to the watts lost in the motor and to the effective dispersal of these losses. At the present day there are three general types of motor in use—namely: (a) enclosed, (b) ventilated, and (c) forced draught; but on the usual one-hour rating these are all brought into line, as by common consent no kind of induced ventilation is permitted for the 60-minute heat run.

TABLE II.—*Outline Data for 600-Volt Interpole Railway Motors at 600 Revolutions per Minute Rated Speed, Field Control.*

Rated output kw.	25	50	100	150	200
Efficiency per cent.	82	84	86	88	88
Input .. .. kw.	31	60	114	171	228
Amperes	52	100	190	286	380
Armature turns ..	480	336	258	215	186
Ampere-turns	12,600	17,000	24,200	30,400	35,200
Flux per pole, megalines, full	4.1	5.9	7.8	9.4	10.8
Flux per pole, megalines, short ..	3.1	4.4	5.9	7.1	8.1
Turns per segment ..	3	2	1	1	1
Commutator segments	160	168	258	215	186
Armature slots ..	40	42	43	43	31
„ diameter, in.	15.0	17.0	19.0	20.6	21.8
„ core-length in.	9.2	10.5	12.6	14.0	14.5
„ D^2L „	2040	3000	4550	6000	6900
Weight, less gear lb.	2380	3050	4750	5950	7100
„ with gear „	2640	3400	5280	6600	7900

The over-all efficiency of a motor allows for losses in the copper, core, and commutator, together with gear and bearing friction and windage. As factors in the temperature rise, however, all but the gear losses are effective. In the short one-hour heat run, these are absorbed in the mass of the machine, there being little radiation with heavy motors; it is therefore justifiable, as proposed by Mr. H. M. Hobart,* to assign a definite value of kilowatts per ton weight of motor for the 75 deg. Cent. temperature rise. This "kilowatts per ton" expression is, however, one of a very approximate nature, and useful only when comparing motors of similar type, size, and ventilation characteristics. This relation of the losses to the mass of the machine shows that the weight cannot be reduced to a radical extent without also designing for an increased efficiency, and that a low-efficiency motor is *ipso facto* a heavy one for its output. The output of a railway motor at rated load is, however, being superseded as a criterion of its service capacity. What is far more important than the one-hour rating is the capacity for continuous operation of five or six hours or even longer periods.

The curves in Fig. 8 throw some light on this point, and referring to these it will be seen that although two different machines may have exactly the same rated one-hour output, efficiency and possibly weight, their performance on runs of longer period is radically different. Motor A, it will be seen, will take much heavier loads to reach its 75 deg. Cent. rise than motor B for two, three, or four hours' running. The former is representative of the recent ventilated designs, and the latter of the totally-enclosed carcase motors, which are only just being superseded by type A. It may be urged that 75 deg. Cent. is an undesirably high temperature rise for a service condition, even for an eight-hour run; but it will be noted that the curves shown relate to stand tests, and the heating in actual service may be assumed to be some 15 per cent. lower, on account of the positive draught produced by the motion of the train.

Actual service, however, does not demand a steady current input, but a very fluctuating one, the values of which can only be predicted by graphical construction of the speed and current-time diagrams. The voltage, too, is a variable quantity, taking into account the number and duration of the stops, coasting periods, &c. It is obvious that the heating, so far as it is influenced by the copper losses, depends upon the square root of the mean of the squares of the varying current input. Further, the core losses are directly proportional to the product of speed and flux, or, in other words, approximately to the impressed voltage. Determination of the R.M.S. current and average voltage from the performance curves will therefore afford a clue as to the average losses and thermal capacity of the motor.

In Fig. 9 are shown the approximate values of the

TABLE I.—*Outline data for 600-Volt Interpole Railway Motors at 600 Revolutions per Minute Rated Speed; Non-Field Control.*

Rated output kw.	25	50	100	150	200
Efficiency per cent.	84	86	89	90	90
Input .. .. kw.	30	58	113	167	222
Amperes	50	97	189	278	370
Armature turns ..	444	320	234	195	170
Ampere-turns	11,000	15,000	22,000	27,000	31,000
Flux per pole, megalines	3.4	4.9	6.5	7.8	9.0
Turns per segment ..	3	2	1	1	1
Commutator segments	148	160	234	195	170
Armature slots ..	37	40	39	39	34
„ diameter in.	14.5	16.0	18.0	19.0	20.0
„ core-length in.	8.0	9.8	11.7	14.0	14.5
„ D^2L „	1700	2500	3800	5000	5800
Weight, less gear lb.	1980	2540	3960	4950	5950
„ with gear „	2200	2800	4400	5500	6600

* "Heavy Electrical Engineering," Chapter XI., page 245.

losses in a 180-kw. railway motor, and Fig. 10 shows the thermal characteristic of the same machine running on stand test. The preponderating factor in the temperature rise at rated load is the copper loss, and at light loads the core and stray losses; consequently a motor for frequent stops and accelerating service should be designed with a view to the lowest possible copper loss, whilst the net saving of 50 per cent. on the equipment weight and of 30 per cent. on its cost. Contrary to general opinion, ventilated motors have been found to operate satisfactorily even under the most adverse circumstances of dusty and gritty ballast.

One of the first types of semi-ventilated motor in general use in England was the G E 66 95-kw. motors confined to locomotives where the equipment is under closer inspection during operation, and it is extremely doubtful whether it would attain any measure of success if generally applied to car-motors.

High-Voltage Motors.—The increase in rated voltage to values higher than 600 followed immediately upon the introduction of commutating poles into railway-motor

Fig. 7. SPEED AND TRACTIVE EFFORT CHARACTERISTIC FOR A 45 KW. MOTOR ON SHORT (S.F.) AND FULL (F.F.) FIELDS.

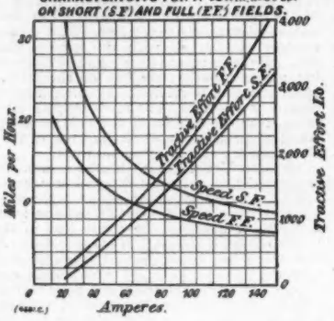


Fig. 8. TIME TAKEN TO ATTAIN 75° C. TEMP.ᴿᴱ RISE ON HOTTEST ACCESS.ᴮˡᴱ PART. (A) Ventilated. (B) Non-ventilated Motors.

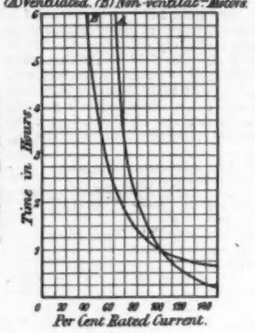


Fig. 9. LOSSES IN A 180 KW. MOTOR.

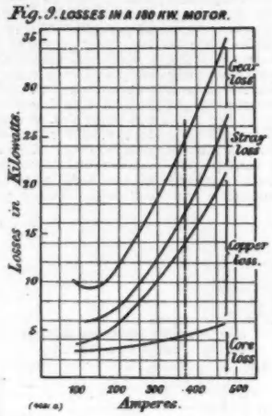


Fig. 10. THERMAL CHARACTERISTIC OF 180 KW. MOTOR (See Fig. 9.) FOR 75 DEG.ᴿᴱ C. TEMPERATURE RISE.

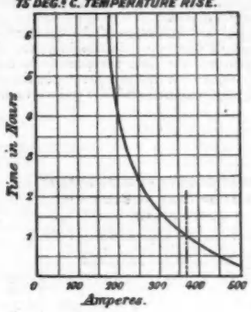


TABLE III.—DATA OF 600-VOLT CONTINUOUS-CURRENT RAILWAY MOTORS IN ACTUAL OPERATION.

Motor.		Output.		Weight.			Speed.		Saturation Factor.	Efficiency.		Operating on
Reference.	Type.	H.P.	Kw.	Less Gear.	With Gear.	Per Kw.	Rated Load.	½ Rated Load.		Less Gear.	With Gear.	
				lb.	lb.	lb.	r.p.m.	r.p.m.		p.c.	p.c.	
A	G E 203	50	37	2170	2640	72	930	1140	1.80	89	85	Twin City Rapid Transit, Minn.
B	W 306	60	45	2645	3030	67	625	1150	1.85	89	85	Pacific Electric RR., Cal.
C	G E 201	75	56	2385	2735	49	680	1120	1.65	89	85	International Ry., Buffalo.
D	W 321	90	67	3680	4150	62	530	970	1.83	89	85	Waterloo and Cedar Falls RR., Ia.
E	G E 205	100	75	3230	3700	49	750	1300	1.73	90	86	Oregon Electric Ry.
F	G E 66	125	94	3900	4400	47	550	980	1.78	91	88	Central London Ry.
G	D K 4A	160	119	6050	6535	55	470	970	2.06	91	88	Lancashire and Yorkshire Ry
H	G E 55A	160	119	5060	5415	41	530	880	1.65	89	86	Boston Elevated RR.
J	G E 248	160	119	5400	5975	50	550	1230	2.23	90	87	New York Municipal Ry.
K	W 86B	200	150	5500	6200	41	650	1090	1.68	91	88	New York Subway.
L	W 308	225	170	6150	6740	40	590	960	1.72	91	88	Southern Pacific RR., Cal.
M	G E 69	240	180	5400	6000	33	540	930	1.72	91	88	London Electric Ry.
N	W 339	275	205	7000	7800	38	570	900	1.58	92	89	L. and S.W. Ry.

All the above are commutating-pole motors, with the exception of F, G, H, K and M. Motor J is a field-control design having a full field 25 per cent. in excess of normal; hence the high saturation factor. This latter quantity is a figure denoting the shape of the speed curve, and is the ratio of the speeds given in the two previous columns.

machine which is expected to run for one or more hours continuously at about one-third rated load should have the lowest possible core loss in order to operate within its temperature limitations. For a given speed low copper loss implies an armature winding of few turns, and consequently a high value of polar flux, which in an armature of given size leads to an increased core loss. At the same time the higher field excitation may lead to a disproportionally increased I^2R loss in the field windings if pushed too far. In many cases better practice is followed by increasing the rated speed in inverse ratio to the armature turns; thus the pole flux is unchanged, the armature I^2R loss is diminished, and the core loss is increased almost in direct proportion to the augmented speed.

The foregoing considerations show that it is impossible to specify for a railway motor on the basis of its one-hour rating alone. Specifications should call for the value of the various losses at two or three different loads, particularly for the average load at which the motor is expected to operate in service.

Reference to Fig. 9 will demonstrate that copper and core losses are far from being the only losses of significance. The stray losses due to journal and commutator friction and windage are all factors in the temperature rise, whilst the gear friction detracts a further 3 per cent. to 7 per cent. from the efficiency according to the speed.

The basis of both the American and European methods of rating railway motors is the 75 deg. Cent. temperature rise in a one-hour run on the test-bed with covers removed and no artificial ventilation. Without having been standardised in England, this system is in very general use here and might quite well be officially adopted. It is usually recognised that the one-hour rating represents the maximum desirable current input for acceleration, and that the average load for a complete day's running should not exceed 30 per cent. rated load for unventilated, or 50 per cent. rated load for ventilated, machines. A tendency is at work to assign a standard for continuous rating, but in view of the widely different classes and requirements of electric service, and the indiscriminate use of ventilated and unventilated motors, little use could at present be made of this.

Ventilation.—Reverting to the curves in Fig. 8 and bearing in mind the fact that the average load on a railway motor is from 25 per cent. to 45 per cent. of its one-hour rating, the value of the present ventilated designs is fully evident. In more than one instance on electric railway systems in America ventilated motors rated at 50 kw. are doing the same work as the 80-kw. non-ventilated machines which they have superseded, with a which are still operating on the Central London Railway. These machines had hollow shafts, admitting air at the commutator end. The shafts were drilled radially, permitting the air to circulate through longitudinal and radial ducts in the armature core. No definite arrangement for the egress of the air seems to have been provided, however. In more recent designs, radial ducts in the core have been quite abandoned in favour of longitudinal passages. The air is admitted usually at the gear end, transmitted between the poles and over the armature surface to the commutator end, where it flows back through the commutator spider and along the core-ducts to the fan, which is fitted at the gear end of the armature core and immediately next the air outlet in the casing. This is known as the series-fan system of ventilation; more recently multiple fans have been introduced, by which the air is all drawn in at one end of the carcase through all the passages in parallel, and expelled at the other end. Thus there is no reversal of the air currents, its volume and velocity are greater, and there is no risk of sucking in the hot air just expelled from the motor, as is the case with the series fan, where the outlet and inlet are necessarily close together. The increased velocity reduces to a minimum the risk of depositing dust or brake-shoe grindings.

In all ventilated motors properly so-called, the air circulation is effected by an exhaust fan of very compact type, usually of aluminium or pressed steel, which is bolted to the armature core and actually forms the end core-plate. The velocity imparted to the air is sufficient to retain in suspension any dust which might enter the casing and to carry it out again. The drawback to the earlier semi-ventilated motor was that no positive velocity was given to the air, and also that the structure of the machines provided dead-ends and pockets, into which the dust, grit, iron oxide, and other particles were driven and permitted to accumulate. The present type of motor with its strong induced draught and clean-cut and direct air-passages overcomes these drawbacks entirely.

Fig. 11 shows skeleton diagrams of (A) the old G E 66 system of semi-ventilation, (B) the series fan, and (C) the multiple-fan methods of ventilation. Either of the latter is subject to modification where desired, as the inlets, or both inlets and outlets, can be closed where conditions require, and the motor will still run cooler than if no fan were installed, on account of the better interior air circulation.

Mention might here be made of forced ventilation by means of air-compressors. This expedient does not seem to be justified, except where it is required to force the output of a motor beyond that obtained by internal ventilation. The device is at present almost wholly

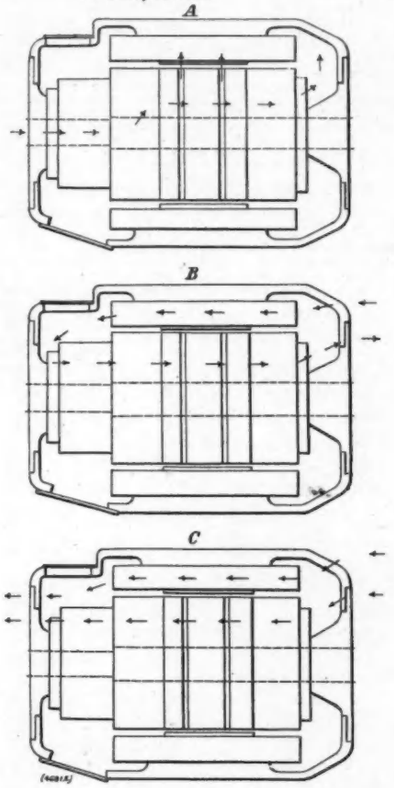
TABLE IV.—*Design Data for* 200-*Kw. Railway Motors, Fully-Ventilated, Field-Control Type. Continuous Capacity,* 100 *Kw., with* 60 *deg. Cent. Temperature Rise.*

Electrical Data:			
Rated voltage	600	1,200	1,800
Efficiency	88	88	87
Current, amperes	380	190	128
,, per circuit	190	95	64
Speed, full field	450	450	450
,, short field	550	550	550
Frequency	15	15	15
Product, turns × pole-flux	1,900	3,800	5,700
Turns on armature	180	288	360
Pole flux .. megalines	10.6	13.7	15.9
Armature ampere-turns	34,300	26,800	23,000
,, ampere-turns per inch	520	405	350
Armature:			
Diameter .. in.	21	21	21
Gross core-length .. ,,	14	18	19.75
Net core-length .. ,,	12.6	16.2	17.6
D²L	5,600	7,140	8,600
Pole arc .. in.	10.7	10.7	11.6
Pole pitch	16.5	16.5	16.5
Total conductors	360	576	760
,, slots	36	36	38
Conductors per slot	10	16	20
Current density amperes per sq. in.	2,500	2,500	2,500
Size of conductor .. in.	0.076	0.038	0.0256
Dimensions .. ,,	0.76×0.10	0.76×0.05	0.30×0.84
Slot space factor	0.50	0.38	0.30
Dimensions of slot in.	1.6×0.87	11.6×0.87	2.0×0.85
Slot pitch .. .. ,,	1.83	1.83	1.74
Magnetic Data:			
Flux density, armature core, kilolines	84	84	90
Flux density, teeth	148	141	149
,, air-gap	65	65	69
,, pole core	108	108	106
,, frame	73	95	110
Ampere-turns, armature core	175	175	210
Ampere-turns, teeth	4,410	3,120	5,400
,, air-gap	5,100	5,100	5,400
,, pole core	315	315	230
,, frame	350	980	2,240
,, total	10,350	9,690	13,530
Resistances:			
Length of armature turn, in.	67	75	78
Turns per circuit	89	144	180
Section of wire .. sq. in.	0.075	0.038	0.0256
Resistance per circuit	0.0634	0.228	0.440
,, between brushes	0.0317	0.114	0.220
Armature current	380	190	128
Voltage drop in armature	12.0	21.6	28.2
,, ,, brushes	2.5	2.5	2.5
Armature I^2R loss .. kw.	5.50	4.60	3.94
Main pole, length of turn, in.	60	68	72
,, number of turns	28	51	105
,, section of wire sq. in.	0.25	0.125	0.070
Main pole, resistance	0.0054	0.022	0.066
Interpole, length of turn, in.	32	40	44
,, number of turns	29	58	87
,, section of wire sq. in	0.25	0.125	0.0625
,, resistance	0.003	0.015	0.049
Total field resistance	0.034	0.148	0.540
Field current	380	190	128
Drop in volts	13.0	28.2	69.0
Field I^2R loss .. kw.	4.95	5.35	8.85
Total I^2R losses at rated load kw.	10.45	9.95	12.79
Total I^2R losses .. p.c.	4.60	4.36	5.60
Commutator:			
Working length .. in.	11.0	5.5	3.7
Total length .. ,,	11.5	6.0	4.2
Diameter .. .. ,,	16.0	16.0	16.0
Number of segments	180	288	360
Width of segment (including mica) .. in.	0.28	0.175	0.14
Volts per segment, average	13.3	16.6	20.0
Number of brushes per stud	4	3	2
Size of brush .. in.	2½×¾	1½×¾	1½×¾

design; commutation was thereby so much improved that an increase of 100 per cent. in the average volts per commutator segment was found permissible. Previous to this, however, it was a common commercial test to run non-commutating-pole motors on the test-bed at 50 per cent., and in some cases at 100 per cent. over-voltage; with the latter designs this was accomplished with a marked absence from flash-over tendencies.

The practicability of increased pressures of 1200 or 2400 volts has greatly broadened the limits of continuous-current working. Where these high pressures are employed it is generally for fairly heavy service of the interurban or extra-suburban order demanding powerful motors; this is a favourable feature, as in common with other classes of electrical machine the high-voltage traction motor becomes a more economical proposition with increasing outputs. As will be surmised, there is a perfectly definite limit to the pressure which can be applied to the motor terminals, and this would appear to be about 2000 volts for car-motors of the type under review.

Fig. 11.
SYSTEMS OF MOTOR VENTILATION.
(A) G.E. 66 Semi-ventilation.
(B) Series Fan.
(C) Multiple Fan.



In any four-pole series motor with a two-circuit armature, the internal voltage at rated load is given by

$$V = 0.02\ N\ \Phi\ f,$$

where

N = total number of turns on armature,
Φ = polar flux in megalines.
f = frequency = r.p.m./30.

Evidently in a motor of given dimensions Φ is limited, and therefore an increased voltage can only be secured by a higher speed or a higher value of the armature loading. Higher rated speeds are being put out of court by the general adoption of field control, apart from the desirability of keeping the commutating constants as good as possible; hence to increase the number of turns in proportion to the higher pressure is the only alternative. The diminishing space factor of the armature-slots, however, prevents this being effected in an armature of given diameter (see Fig. 12).

In another direction some latitude is permissible; with increased voltage, of course, the current to be commutated is reduced; consequently the commutator can be shortened in almost the same proportion. This applies to the working length, and assumes a fixed brush width, though there may be cases where with a very high voltage the circulating currents between the toe and heel of the brush would necessitate a narrower brush. It is, however, generally found that the working length of commutator for 1200 volts need be only half that required for 600 volts. Every inch by which the commutator is reduced may be added to the core length, thus immediately securing an increase in the effective flux passing through the armature. This very nearly compensates for the reduced armature loading consequent upon the low space factor in the slots, and leads to the interesting conclusion that, with given dimensions, the higher-voltage motor needs to be designed for a stronger field and weaker armature. This is just the tendency required for a satisfactory design.

Table IV., on page 26, outlines the preliminary design features for three railway motors of 200 kw. rated output at 600, 1200, and 1800 volts respectively. The output has been taken as typical of that most commonly in demand for the railway electrification work now in progress. For the reasons already given the most powerful motor which can be economically used is the most satisfactory. At higher voltages this is still more true, on account of the improved slot-space factor accruing from the use of large strap conductors, wide rectangular slots, and the general cheapening of the design.

The two limits governing commutator design in high-pressure motors are the maximum permissible voltage per segment and the minimum segment width. It is evident that with one turn per segment, if the number of armature turns be increased, either the commutator diameter must also be raised or the bar narrowed down. Little latitude is available for the increase of dimensions, and the minimum allowable width of bar, including mica, is about 0.16 in., so that a definite limit is fixed in this direction. The limiting desirable average voltage per segment is believed to be 20 for a reasonably good field distribution. High-voltage design calls for low commutator speeds; and even though interpoles are fitted, it is necessary to keep the commutating constants as conservative as possible.

If all these conditions are complied with, the design and manufacture of a satisfactory 1200-volt motor is a simple matter, and that of an 1800-volt machine, whilst being a slightly more heavy and costly proposition, is very little more so. Higher pressures than this do not seem necessary in view of the practicability of connecting groups of two or four motors permanently in series.

The three designs tabulated herewith are worked out for the same carcase and the same armature boring. The pole seating in the 600-volt carcase permits of the extra punchings being added for the longer-cored high-voltage machines. According to the rated speed a field frame is generally employed for at least three different outputs of machine at the same pressure, so that if the same casing can be used for three different pressures, at least nine different forms of motor can be constructed from the same patterns. As will be seen, this gives reasonably good designs for the 600 and 1200-volt motors, but owing to the high magnetic densities reached in the 1800-volt machine, it would seem to be improved by reducing the rating about 10 or 15 per cent. It is, however, sufficiently worthy of note that the same motor carcase which will give 200 kw. at 600 volts will also yield 180 kw. at three times this potential. Fig. 13 shows a longitudinal section of the 1200-volt motor.

Fig. 12. SPACE FACTORS FOR RAILWAY MOTOR ARMATURE-SLOTS, MICA INSULATED.

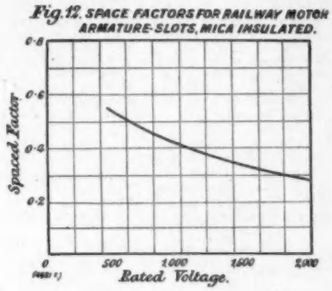
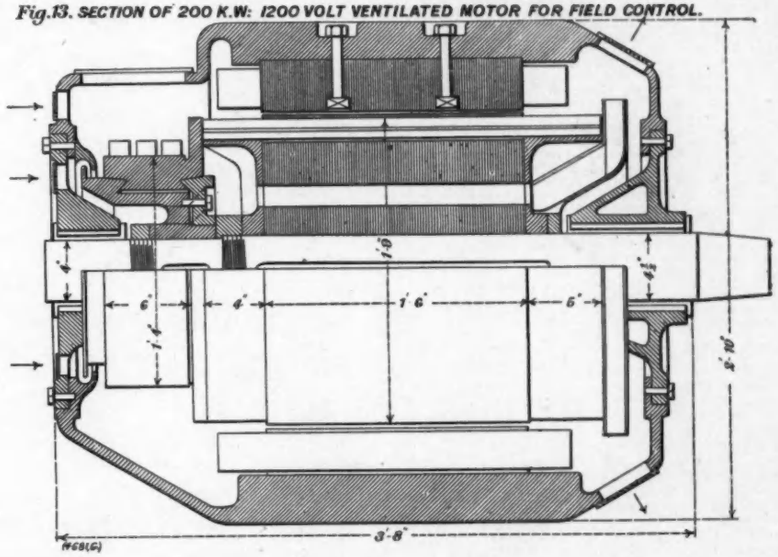


Fig. 13. SECTION OF 200 K.W. 1200 VOLT VENTILATED MOTOR FOR FIELD CONTROL.



This paper is not intended to be a complete treatise on railway motors, but merely to summarise a few of the improvements which have been effected in this class of machine during the last few years and the main features of its present design. There is room for much more to be written on the subject, particularly on the behaviour of high-voltage motors in actual service.

The author's thanks are due to the Canadian Westinghouse Company and the British Westinghouse Company for some of the information contained in this paper, and to Mr. W. G. Gordon, of the Canadian General Electric Company, for many useful suggestions.

APPENDIX.

EXTRACT FROM THE STANDARDISATION RULES OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Railway Motors, Rating.

Nominal Rating.—The nominal rating of a railway motor shall be the mechanical output at the car or locomotive axle measured in kilowatts, which causes a rise of temperature above the surrounding air by thermometer not exceeding 90 deg. Cent. at the commutator and 75 deg. Cent. at any other normally accessible part after one hour's continuous run at its rated voltage (and frequency in the case of an alternating-current motor) on a stand with the motor-covers arranged to secure maximum ventilation without external blower. The rise in temperature as measured by resistance shall not exceed 100 deg. Cent. The statement of the nominal rating shall also include the corresponding voltage and armature speed.

Continuous Rating.—The continuous ratings of a railway motor shall be the inputs in amperes at which it may be operated continuously at ½, ¾, and full voltages respectively, without exceeding the specified temperature rises, when operated on stand test with motor-covers and cooling system, if any, arranged as in service. Inasmuch as the same motor may be operated under different conditions as regards ventilation, it will be necessary in each case to define the system of ventilation which is used. In case motors are cooled by external blowers, the flow of air on which the rating is based shall be given.

SHIPBUILDING IN CANADA.—The City of Three Rivers, Quebec, is offering free sites, exemption from tax and other inducements to shipbuilders and others to lay down plant in that city. Three Rivers proper is situated on the North Shore of the St. Lawrence, midway between Montreal and Quebec cities, the distance being about 75 miles each way. The harbour affords all the facilities required for modern ocean traffic. Its wharves are over 2 miles in length, mostly of concrete, and the water has a depth of over 50 ft. with a tide water rise of 12 to 14 in. The Canadian Pacific, the St. Maurice Valley, and the Grand Trunk Railways place the city in direct communication with all the business centres in Canada and the United States. The St. Maurice River itself, which is about 300 miles long, and has 20 odd important tributaries, furnishes, within 30 miles of its mouth at Three Rivers, six large falls and two rapids, which together can develop about 1,000,000 electrical horse-power, 250,000 horse-power only of which is at present made use of. There is an abundant supply of skilled and cheap labour. One industry which commenced operations in 1909 with 12,500 spindles is now operating 75,000 spindles and employs over 1,000 hands. Lieut.-Col. P. Pelletier, the Agent-General for Quebec in London, would be glad to send booklets, plans and any information needed, or direct application could be made to W. Jos. Shea, Industrial Commissioner for the City of Three Rivers.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

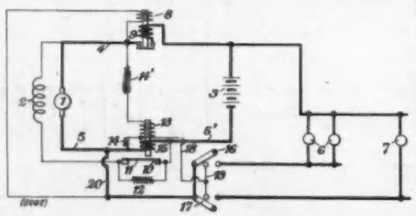
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

8602/15. Igranic Electric Company, Limited, London. (*The Cutler-Hammer Manufacturing Company, Milwaukee, U.S.A.*) **Regulating Electrical Circuits.** [5 *Figs.*] March 31, 1915.—This invention relates to circuit-regulators of the type which operate automatically to regulate the output of a generator to that required to charge a battery when there is no current consumption, and automatically varies the standard of regulation and reduces the voltage of the system when there is current consumption. It has particular reference to regulators of the aforesaid general character which involve a vibrating relay energised by a shunt winding and controlled by electro-magnetic means in response to electrical conditions in the circuit, the effectiveness of the electro-magnet being automatically varied by means of a resistance in series with the shunt winding to vary the standard of regulation when the electrical conditions in the circuit are changed. The present invention consists in the employment in a regulator of the foregoing type, provided with a vibrating relay and having a resistance inserted in the shunt circuit of the relay, and not in series with the lamps of an arrangement of switches whereby the closure of any one of the load circuit switches will short-circuit the resistance in the shunt. 1 is the armature of a generator and 2 the shunt field. A storage battery 3 is connected to the armature by generator leads 4 and 5. 6 and 7 represent a lighting load. An automatic switch may be provided in one generator lead which has a lifting-coil 8 connected in shunt across the generator and a holding-coil 9 connected in series in the generator lead. The shunt-coil 8 is adapted to operate the switch to close the circuit between the generator and battery when the voltage is sufficiently high to charge the battery. The series and shunt-coils act together to maintain the switch closed. If the generator voltage falls below the battery voltage the battery will tend to discharge through the generator, thus reversing the series coil 9 and causing the switch to open. The automatic regulator controls the generator output by varying the effective resistance of the shunt-field circuit. The regulator comprises a contact 10 carried by a vibratory armature 11 adapted to open and close rapidly a short circuit around a resistance 12 in the shunt-field circuit. The character of vibration of the contact 10 determines the effective value of the resistance, as the value of the resistance is, of course, its mean value, and is proportional to the length of the time the resistance is in circuit. The vibration of the armature is controlled by electro-magnetic windings having a high resistance coil 13 connected across the generator leads through a

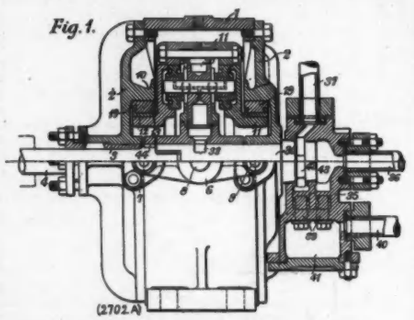


resistance 14 and a comparatively low resistance coil 15 connected in series in the battery lead 5^1. A lamp-switch 16 controls the lights 6 and a switch 17 controls the lights 7. The closure of either switch 16 or 17 serves to short-circuit the resistance 14 in circuit with the regulator shunt-coil. The operation of the system is as follows:—When the generator starts to operate, its voltage will be insufficient to open the short-circuit around the resistance 12. Consequently, the generator voltage will rapidly build up until, at a predetermined speed, the voltage will be sufficient to cause the automatic switch to close the charging-circuit to the battery. As the generator speed further increases, current flowing through the series-coil 15, acting in conjunction with that in the shunt-coil 13, will operate the vibratory contact to vary the field excitation, thereby controlling the generator output. It is a well-known fact that as the storage battery is charged its potential increases, reaching, finally, in the case of a lead battery, a potential of 2.5 volts per cell when fully charged. As the battery voltage rises, the voltage impressed upon coil 13 will rise accordingly. Since the vibratory contact 10 is operated by the combined force of the series-coil 15 and the shunt-coil 13, it is obvious that the higher the potential of the battery the lower the current which will be necessary in series coil 13 in order to accomplish the vibration of vibratory contact 10. By varying the proportions of these coils any desired charging characteristic may be given to the battery. It is preferable in most cases to so proportion the coils as to provide a taper charge. Operating coil 13 being ordinarily wound with copper wire, a continued flow of current through this winding will cause a rise in its temperature which will increase the resistance of the coil, and thereby reduce the current flowing through it to such an extent as to noticeably vary its effectiveness. To compensate for this increase in resistance, a resistance 14^1 may be connected in series with the coil 13. If this resistance is of substantially zero coefficient, and if its value is relatively high as compared with that of the coil 13, the increase in resistance due to the heating of the coil 13 will be negligible in proportion to the entire resistance of the shunt-coil circuit, so that the coil 13 will exert a predetermined pull for a given voltage on the system regardless of its temperature rise. Upon closure of either lamp-switch a short-circuit will be established around the resistance 14, and the circuit for the coil 13 will be from lead 4 through the coil 13, through conductor 18, the cross-connection 19 between the lamp-switches and conductor 20, to the lead 5. The effect of the regulator shunt-coil 13 will be immediately increased so as to cause this coil to predominate in the regulation. As a result, a substantially uniform voltage will be maintained, but at a voltage somewhat below the maximum charging voltage of the battery, so that lamps which will satisfactorily operate at the battery discharging voltage may be operated directly from the battery charging generator without the interposition of a compensating resistance in the lamp circuit. (*Sealed.*)

PUMPS.

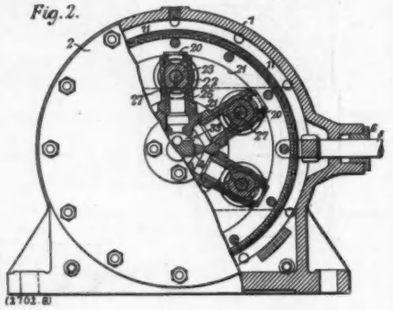
2702/15. H. S. Hele-Shaw and F. L. Martineau, London. Rotary Pumps and Motors. [5 *Figs.*] February 19, 1915.—This invention relates to improvements in rotary pumps and motors, and has reference to pumps and motors of the type wherein a cylinder body rotates about a stationary central valve, and the pistons within the cylinders derive their movement of reciprocation by co-operation without definite attachment with an eccentrically-situated ring, which ring revolves or floats round in company with the cylinder body. The object of the present invention is to simplify the construction, to reduce the cost of manufacture and render certain of the internal parts interchangeable and more readily accessible, and to eliminate noise. The invention consists of a particular construction and arrangement, the primary feature of which is the use throughout of plain bearings which involves special means of effecting lubrication. Another feature consists in the provision of a removable fitment carrying the inlet and outlet pipes and the usual make-up valves, and this involves the provision of a central valve designed to accommodate this fitment. Another feature consists of the method of making the central valve designed for simplicity and cheapness of manufacture. The numeral 1 designates a central cylindrical casing member, and this casing member is closed upon either side by means of cir-

Fig. 1.



(2702.A)

Fig. 2.



(2702.B)

Fig. 4.

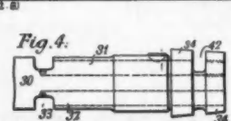



Fig. 5.

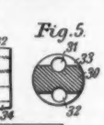
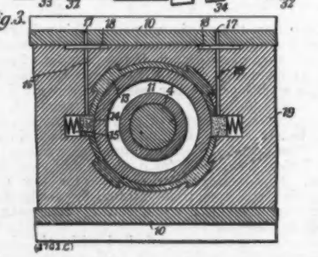


Fig. 3.



(2702.C)

cular side walls 2, one of which is provided with a stuffing-box bearing 3 to support the central shaft 4, and glands or stuffing-boxes 6 and 7 may be provided, if necessary, to accommodate and guide the central rod 8 and supplementary parallel side rods 9 respectively. The flanges of glands 7 are preferably arranged lying in the same direction and immediately opposite one another, in the manner illustrated. The outer side walls 2 are provided with wells or oil-receiving grooves 10 adapted to catch lubricant which is delivered to them in the form of spray as the eccentric ring or drum 11 rotates, in the manner well known. The eccentric ring, which is usually provided with means, such as the central rod 8, and parallel side rods 9 before referred to, whereby its position relative to the central axis of the machine can be varied to vary the stroke of the pistons of the machine, is mounted to rotate upon plain bearings 12, preferably faced with white metal 13, and at one or more positions a felt or other pad 14 extends through the white metal into wiping contact with the surface which rotates against it, and this pad may be kept in position by means of the spring 15, and it is continuously charged with lubricant by means of holes or passages 16, 17 leading to it from the wells or oil-storage grooves 10 formed as aforesaid in the casing-walls 2, these wells or grooves 10 acting as a continual oil supply. The particular arrangement adopted in respect of each of the pads 14 is to provide a passage or passages 17 leading from the oil-wells or grooves 10 to a recess 18 cut in the upper edge or surface of the sliding-member 19 which carries the bearing. The passage or passages 16 leads from this recess to the pad 14 and effectually lubricates it, as will be readily understood upon reference to Fig. 3. It will be understood that the recesses 18 are of such a length that there is communication with the passages 17 in all positions of the sliding-block 19. This really means that the recesses should be slightly longer than the maximum travel of the block 19 to impart maximum eccentricity to the stroke-controlling drum 11 in either direction. The pistons 20 co-operate with tracks 21 upon the eccentric-ring or drum 11 through rollers 22, which are mounted upon gudgeon-pins 23 passing through the pistons and through slots 24 in the walls of the cylinders 25. These rollers 22 are plain bearing rollers, bushed or faced with white metal 26, and their bearings are lubricated preferably by means of channels 27 having branches 28 cut or drilled in the gudgeon-pins, and the lubricant is delivered to these channels from the cylinders 25 of the machine—where oil is the working fluid, as is usually the case with this type of apparatus—small holes 29 leading from the pistons to the passages aforesaid in the gudgeon-pins. The central valve 30 is constructed from a cylindrical member which is turned to the required size and shape, and the inlet and outlet passages 31 and 32 are drilled, and slots 33 are machined out to form ports, about which the cylinders rotate. The end 34 of the valve is coned to receive the fitment 35, which carries inlet and outlet pipes 36 and 37 and the usual leakage make-up valves 39, a pipe 40 leading from a make-up tank to the chamber 41. The make-up valves 39 are duplicated, and one communicates with a groove 42 cut in the valve, which groove is in communication with the valve-passage 31, and the other leads to the chamber 43, which is in communication with the other valve-passage 32, which is drilled right through the end 34. Thus one or other of the make-up valves 29 is in communication with whichever of the passages 31 and 32 is the suction-passage at the moment. The cylinder body is keyed or clutched at 44 to the driving-shaft 4 by which the cylinders are continuously rotated, and the pistons 20 reciprocate with a stroke dependent upon the degree of eccentricity imparted to the stroke-controlling ring or drum 11, and the direction of inlet and discharge will depend upon which side of the axis the drum 11 is adjusted. (*Accepted February* 16, 1916.)

SHIPS AND NAUTICAL APPLIANCES.

24,230/14. Vickers, Limited, and T. G. O. Thurston, London. Protection of Ships. [18 *Figs.*] December 17, 1914.—This invention relates to devices for the protection of ships from the effect of a submarine explosion, such as that resulting from a mine or torpedo. According to this invention, a protective structure is provided which is more or less of U-shape in cross-section—that is to say, it comprises side walls connected together by a transverse portion adapted to lie beneath the ship's hull, the structure being of such a character that it can be caused to float at a suitable depth in the water to permit of the ship to be protected being floated into the structure, whereupon the latter can be secured to the ship by any suitable means. The protecting structure, although possessing sufficient buoyancy to float at the proper depth in the water, does not have any material effect upon the buoyancy of the ship itself; it does, however, exert an upward pressure on the bottom of the ship, which pressure will operate as an additional means of holding the protective structure in position relatively to the ship; furthermore, the protective structure does not prevent the propulsion of the ship (together with the structure) by the ship's propeller or propellers. A represents the hull of the ship to be protected; B, B represent the sections of the protective structure; and B^1, B^1 represent the side walls of these sections. Movable portions or members are provided at the aft end of the protective structure for enabling the ship to enter or leave. In the form of the protective structure shown the aft end of the structure is left open, and the distance between the sides at the aft end is made greater than the maximum beam of the ship, so that the latter can be readily floated into position. The foremost or bow section of the structure conforms more or less to the shape of the ship's bows. This section may carry a bilboard B^x for guiding the anchors when they are being dropped. The transverse portions or floors of the various sections may be continuous, as is the case with the foremost or bow section in the construction shown, or may be interrupted, as shown at the aft or stern section. The transverse

Fig. 1.

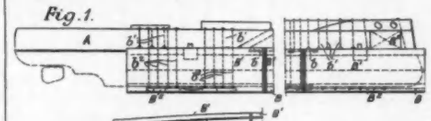


Fig. 2.

(24230)

portions or floors may be formed with large openings in order to permit a free flow of water in the vertical direction whenever the ship is in a seaway. The sections are connected together by ropes or chains *b*; the sections are secured to the ship by two series of ropes or chains b^1, b^2, the first series being attached to the upper ends of the side walls B^1 of the sections, and the other series being attached to the transverse portions or floors; each of the ropes or chains is connected to a shackle, winch or the like arranged inboard. The ship may be centred by chocks carried by the transverse portions or floors B^2, and the side wall B^1 of the sections may be held at the desired distance from the hull by means of pivoted struts or shores b^3. The side walls and the transverse portions or floors of the sections are preferably composed of double walls consisting of steel plates and distance-pieces suitably riveted together, and may be divided into independent compartments or chambers which may be wholly or partly in communication with the external water or made water-tight and adapted to contain air or gas (under pressure if desired), oil, water, wood, or other suitable gaseous liquid or solid substance, any one of which substances may be used alone or in addition to any of the others. The movable portions or members are, in the example shown, composed of perforated metal plating suitably connected to wood beams. At the upper end the members carry floating chambers, and between each of these chambers (except the foremost one) and the ship's hull a strut is placed, this strut being pivoted to the chamber and having at its inner end a wood block for bearing against the ship's hull. The chambers are held in the desired position by ropes at each end passing inboard. The foremost members are suitably connected to the side walls B^1 of the aft protective section—for example, by two rods pivoted to brackets on the side walls B^1, and connected by universal joints to suitable portions of the members. The intervals between the members and the side walls B^1 are preferably provided with appropriate metal protective netting. (*Accepted February* 23, 1916.)